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Contents.

	PAGE
The Prospects of Magnesium	387
The Iron and Steel Institute	388
Swiss Iron Foundry Industry	389
Gazette	389
Correspondence	390, 406
Stanton Iron Works Visited	390
Magnesium and its Alloys	391
"Moulders" of the Industry	392
The Shrinkage of Metals	393
Wavelength Tables	396
Safety First and Foundry Goggles	396
An Apprenticeship Course in Foundry Practice.—XLIII.	397
Notes on Grey Iron for Automotive Castings	399
South Staffordshire Iron and Steel Institute	403
Institution of British Foundrymen	404
Trade Talk	406
Company News	406
Obituary	406
Open Contracts	406
Iron and Steel Markets	408

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institution of British Foundrymen.

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The Prospects of Magnesium.

The time has now arrived when the British non-ferrous foundryman should take stock of his at present limited range of alloys, and ascertain for himself whether he should not get right in at the inception of the use of magnesium as an engineering entity.

The metal magnesium was first isolated by Liebig in 1830. It was for a very considerable period neglected by the practical metallurgist. Little was known about its physical characteristics, and the demand for the metal was not sufficient to warrant its production upon a reasonable commercial basis.

It was well known, however, that, when heated much above its melting point, magnesium burned with a very bright flame. In the case of a very thin strip of metal this melting could be effected by means of a match. Moreover, it was found that, suitably mixed with material to supply oxygen, powdered magnesium made an excellent flashlight powder.

For uses such as these the metal was originally manufactured in this country. Later on, the lightness of the metal fired the imagination of first one investigator and then another, and many series of alloys of magnesium with other metals were explored. As a result of this work the well-known Duralumin and Magnalium alloys were produced. These alloys contain over 90 per cent. of aluminium, with which a few percentages of magnesium and other metals are alloyed.

Others set out to investigate the physical properties of alloys containing very high percentages of magnesium.

The coming of the airship and the aeroplane gave an added interest to these researches, for it was felt that all possible advantage should be taken of the extraordinary lightness of magnesium, which is 40 per cent. lighter than an equal volume of aluminium.

During and since the war a great deal of time and work have been expended on the alloys of magnesium. Not much of this work has been published or has become general information. One learns with astonishment that actually thousands of pistons cast from an alloy containing nearly 90 per cent. of magnesium are in use in motor-car engines in this country alone. It is interesting to know that, for purposes where lightness combined with strength is required, large and intricate castings are daily being made in such alloys.

The interest in magnesium is growing day by day among founders, for they see in its use the solution of many difficulties. Many far-sighted founders benefited by bringing aluminium into general use. He would be a very bold man who would state that, for many purposes, magnesium will not supersede aluminium.

Large plants producing metallic magnesium by various electrolytic processes exist in this country, France, the U.S.A., Germany and Scandinavia. The raw material used by the premier British company is magnesite, which is found in large quantities in many parts of the world. In case of emergency, the dolomite quarried in England could be employed.

The quality of the metal produced by the Ashcroft process (the one used in England and France) is exceptionally high. The metal is practically chemically pure.

Alloys made up from metal such as this can be cast in sand or chill moulds, extruded, drawn, forged, stamped and rolled.

The old prejudice that magnesium articles are liable, if not to spontaneous ignition, at least to be set on fire with ease, is now, surely, extinct. It is necessary to melt magnesium before it will catch fire, and then the free access of oxygen is necessary to continue any burning so started.

Elsewhere in this issue, the properties of the metal are outlined and contrasted with those of aluminium. The very practical hints given by the author, Mr. H. J. Maybrey, should enable non-ferrous foundrymen to start their experiments with a good deal of confidence. In conclusion, we would emphasise that price considerations in respect to magnesium require examination in different light from most articles of commerce, and owing to its extreme lightness, a volume basis should be visualised. Expressed familiarly, foundrymen buying this metal on a weight basis get a considerable quantity for their money.

The Iron and Steel Institute.

ANNUAL MEETING IN LONDON.

The Annual Meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday of this week, Mr. Francis A. E. Samuelson (President) occupying the chair.

At the opening of the first day's proceedings yesterday (Thursday), the minutes of the last General Meeting were taken as read and confirmed, and Mr. Henry Dale and Mr. W. Cross were appointed scrutineers of the ballot for the election of new members.

Report of Council.

The Council of the Institute, in their report on the proceedings and work of the Institute during the year 1922, state that during the year 84 new members and 9 Associates were elected and 9 associates were transferred to membership, the total membership on the register of the Institute on December 31, 1922, being made up as follows: Patron, 1; Honorary Members, 6; Life Members, 80; Ordinary Members, 2,113; Associates, 37; total, 2,237. Sixty-seven Members and two Associates resigned their membership, and the names of 53 Members and 3 Associates were removed from the register owing to the non-payment of their subscriptions. During the year the deaths of 24 members have been reported.

Finance.—The statement of accounts shows that the income for the year was £7,964, exclusive of the Carnegie Scholarship Fund, and the expenditure was £7,939, as compared with £8,349 and £6,866 respectively in 1921.

The principal item in the expenditure, apart from salaries, is on account of the printing of the "Journal." The charges maintained by the printing trades are still exceedingly high, and the expenses involved in the preparation of illustrations are likewise considerably above pre-war rates. A further point is that the rent for the Institute offices has also been increased. On the other hand, it is satisfactory to note that, despite the long-continued state of trade depression, a further increase in the membership is to be recorded.

Andrew Carnegie Research Scholarships.—Grants were made by the Council, on the recommendation of the Carnegie Scholarship Committee, to the following candidates:—

A. Bramley (£100) for investigations on the carburising and decarburising effects of different gases on iron and steel.

A. L. Curtis (£100) for investigations on steel moulding sands and their behaviour under high temperatures.

O. W. Ellis (£100) for investigations on the effect of constitution on malleability at high temperatures.

J. N. Friend (£100) for researches on corrosion.

A. M. Parkin (£100) for investigations on the influence of heat treatment and variable carbon content upon magnet steel of constant tungsten composition.

G. V. Phragmen (£100) for investigations on the specific weight of molten metals.

W. E. Williams (£100) for investigations on X-ray spectrography as applied to examining the structure of steel.

Appointment of Representatives.—The President continues to represent the Institute on the General Committee of the Royal Society for administering Government Grants for Scientific Investigations. Sir Robert Hadfield, Bart., F.R.S., and Professor Henry Louis represent the Institute on the Board of the National Physical Laboratory, and Sir Hugh Bell, Bart., represents the Institute on the Board of Governors of the Imperial College of Science and Technology. The Institute representatives on the British Engineering Standards Association are Dr. A. Cooper, Mr. M. Mannaberg, and Mr. B. Talbot. On the Sub-Committee of that Association, for the Standardisation of Galvanised Sheets, Mr. C. Dorman continues to serve; while Mr. H. J. Yates and Dr. W. H. Hatfield are the Institute representatives on the Sub-Committee for Cast Iron working under the direction of the Sectional Aircraft Committee; Mr. J. H. S. Dickenson represents the Institute on the Technical Committee of Motor Industries; and Mr. F. W. Harbord on the Sectional Committee for Chemical Engineering. On the newly-formed Sub-Committee for the purpose of preparing standard specifications for cement from blast-furnace slag, the Institute is likewise represented by Mr. Harbord. Lord Invernairn of Strathnairn, Mr. H. Brearley, Mr. J. H. S. Dickenson, Mr. D. Flather, and Dr. W. H Hatfield represent the Institute on the Committee on Special Steels for Automobile and Aircraft Construction of the Institution of Automobile Engineers. Mr. Harbord is the representative on the British Refractories Research Association, and Dr. Cooper, Mr. Mannaberg, Mr. G. Hatton, C.B.E., and Mr. Talbot represent the Institute on the Committee on the Improvement and Development of Basic Slag, formed by the Ministry of Agriculture and Fisheries. Professor T. Turner represents the Institute on the British Cast Iron Research Association of the Department of Scientific and Industrial Research. On the Technical Committee of Lloyd's Register of British and Foreign Shipping the Institute is represented by Lord Invernairn and Mr. L. Ennis. Sir Robert Hadfield, Bart., F.R.S., and Professor Louis represent the Institute on the Conjoint Board of Scientific Societies, and Sir Robert Hadfield also represents the Institute on the British Association Fuel Economy Committee, on the Court of Sheffield University, and on the Home Committee for the University of Hongkong; while on the Courts of Liverpool University and of Bristol University the Institute is represented by Sir W. Peter Rylands and Mr. W. R. Lysaght, C.B.E., respectively. Mr. Harboard is the representative on the Advisory Board of the Royal School of Mines, and, with Sir Robert Hadfield, represents the Institute on the Federal Council for Pure and Applied Chemistry.

Changes on the Council.—Mr. Francis Samuelson having been elected to the Presidency of the Institute, Sir Frederick Mills, Bart., was elected a Vice-President to fill the vacancy thus created, Mr. John Craig, C.B.E., being elected a member of Council in his place. His Honour Judge Elbert H. Gary has been made an Honorary Vice-President to fill the vacancy occasioned by the death of Professor Howe, and Dr. Carl Benedicks has been added to the list of Honorary Vice-Presidents.

The names of the Vice-Presidents and Members of Council who were announced at the Autumn Meeting as being due to retire at the annual meeting in 1923 were:—*Vice-Presidents*: Mr. C. J. Bagley, Sir William H. Ellis, G.B.E., Mr. M. Mannaberg. *Members of Council*: Mr. F. W. Gilbertson, Mr. E. H. Saniter, Mr. John Craig, C.B.E., Professor H. Le Chatelier, and Sir John S. Randles.

Statement of Accounts for 1922.

Mr. Illtyd Williams (Hon. Treasurer), in presenting the accounts for 1922, hoped the members would derive some satisfaction from the fact that even the very small amount of £24 19s. 8d. appeared as surplus of income over expenditure, because for several months Mr. Lloyd (the Secretary) and he had before them the fear that they would end the year on the wrong side. The variation in membership, details of which were given in the Report of Council, meant, taking all the items together, a reduced income of £233 15s. 7d. The very anxious period through which their industries passed in 1921 and 1922 affected them in two ways—by decreasing the number of new members, and by causing many resignations. A somewhat depressing feature was the decrease in receipts from "Journal" sales by £192 odd. Another item calling for remark was "Journal Publishing Expenses," which had increased by £303. Whether the cost of that work would ever come down to a moderate figure again it would be unwise to prophesy, but to illustrate its very seriously increased charge upon them, cer-

tain particulars of the costs for 1922 and 1913—the last complete pre-war year—were interesting. In 1922 the two Vols., containing some 1,200 pages between them, cost £1,952 17s. 10d. for printing, binding and paper. In 1913 the two Vols., containing 1,557 pages, cost for the same items £1,265 9s. 1d. The only other item to which he would call attention was that of "Bessemer Medals." It would be remembered that during the war period, although the honour of conferring the Medal was continued, it was rightly thought to be unpatriotic to use the gold, and the actual Medals were withheld on two occasions. Those had now been presented to the recipients.

The Report and Statement of Accounts were unanimously adopted.

Presentation of the Bessemer Medal.

The PRESIDENT, in presenting the Bessemer Gold Medal to Dr. Maw, gave a brief outline of the recipient's career, recalling how in 1855 he became pupil of the Eastern Counties Railway Works, now the Great Eastern Works, at Stratford, under the late Mr. John Gooch. In 1865 he left the G.E.R. to join the late Mr. Zerah Colburn in the establishment of "Engineering." Early in 1870, Mr. Colburn ceased his connection with that journal and Dr. Maw was joined in the editorship by the late Mr. James Dredge, the paper being carried on under their joint editorship until the death of Mr. Dredge in 1906. Dr. Maw had done a great work for the advancement of engineering practice, and had assisted in many ways the development of new processes and appliances. From 1870 until within a few years ago Dr. Maw had an independent practice as a consulting engineer, his chief work being in connection with engine and boiler construction, the design and arrangement of workshops and similar buildings. He was also consulting engineer for several important firms, and one particular phase of his work was the fitting of printing machinery for some of the great daily newspapers. He was one of the founders and Presidents of the Civil and Mechanical Engineers' Society, but perhaps the Institution which had profited most by Dr. Maw's work had been the Institution of Mechanical Engineers, of which he was President in 1901 and 1902. He joined the Institution of Civil Engineers in 1896, and in 1903 delivered the "James Forrest" lecture. In 1911 he was elected a Member of Council, Vice-President in 1918, and President in 1922. He was elected a Member of the General Committee of the N.P.L., and was appointed to serve on the Executive Committee in 1905. For the B.E.S.A. he had done remarkable work. He was a Member of the Committee responsible for the foundation of the Association, and still continued to be a Member of, or Chairman of, most of the principal Committees of that body. Dr. Maw was almost as well-known for his work in astronomy as for that in engineering. Both at his town and country residences he had observatories in which he had spent many hours, and the one at Outwood was entirely built by local labour from drawings and templates made by himself. He was elected a Member of the Royal Astronomical Society in 1888, and in 1892 became a Member of the Council. In 1900 he was elected Treasurer, and became President in 1905. Dr. Maw was elected a Fellow of the R.G.S. in 1890, and of the Royal Microscopical Society in 1892. He was also a Member of the Board of Studies of the University of London, and in that connection it might be mentioned that, in 1909, the University of Glasgow conferred on him the degree of LL.D. It was a great gratification to himself as President, to the Council, and to all the Members, to have the privilege of conferring the Bessemer Medal upon Dr. Maw.

DR. W. H. MAW, in returning thanks to the President, and through him to the Council and the Members, said the award had an additional value to him from the way in which it connected him with Sir Henry Bessemer. He was first introduced to Sir Henry Bessemer at the London Exhibition of 1862. At that time they were experimenting with, and using to a certain limited extent, steel for locomotive axles and tyres on the Great Eastern Railway. Sir Henry Bessemer had a most interesting exhibit at the Exhibition, and he (Dr. Maw) spent a good deal of time with him in going through it and learned much by what he was told. He did not meet Sir Henry Bessemer again for two or three years, and then they became intimate friends, and the friendship, he was glad to say, lasted up to the time of Sir Henry's death.

Alteration of By-Law 10.

The PRESIDENT said it would be remembered that at the Autumn Meeting at York in September, 1922, notice was given that a resolution would be submitted at the Annual Meeting in May, 1923, proposing an alteration of By-Law 10, specifying the period during which the President should hold office. The terms of the resolution were:—"That the first two lines of the present By-Law 10 which read: 'The President shall be elected for two years and shall not be eligible for re-election until after an interval' shall be altered to read as follows: 'The President shall be elected for one year,' and that the words 'and shall not be eligible for re-election until after an interval' be omitted." No notice of any amendment to that resolution having been given at the last meeting, he would now put the resolution to the meeting for its acceptance or rejection.

The resolution was then put and declared by the President to be carried unanimously.

The scrutineers reported that, as a result of the ballot for the election of new members, all the gentlemen whose names were on the voting list had been unanimously elected.

Swiss Iron Foundry Industry.

According to a report appearing in "Die Kurve" (Basle) of recent date, forwarded to the Department of Overseas Trade by the Commercial Secretary at Berne (Mr. F. C. D. Rawlins), the Swiss iron foundry industry is experiencing serious difficulties. A number of foundries was closed down in 1922, while the working of the majority of the remaining establishments resulted in a deficit on account of the low prices which Swiss works have been forced to quote in order to be able to compete.

The Union of Swiss Foundries endeavoured to obtain for its members all scrap iron as it became available in Switzerland. Notwithstanding the efforts of the Union, some 70,000 tons were exported which could have been handled by the Swiss foundries.

There are no prospects of a forthcoming improvement. Retail prices have not been influenced so far by the scarcity of raw materials, chiefly iron and coal, or by the simultaneous heavy increase in prices resulting from the occupation of the Ruhr. An increase in retail prices will, however, become unavoidable if the continued existence of the Swiss foundries is to be assured.

Gazette.

THE CHESTER BRASS & IRON FOUNDRY COMPANY, LIMITED, is being wound up voluntarily.

MR. J. M. WELLINGTON, 224, High Street, Stratford, engineer, is paying a first and final dividend of 4s. 10d., at Bankruptcy Court, any day except Saturday between 11 and 2.

RAYMOND & MONYPENNY, trading under the style of Messrs. C. W. Raymond & G. P. Monypenny, 395, Lockner Road, Kingsland, engineers' pattern makers, have dissolved partnership.

MR. N. R. DICKINSON (described in receiving order as Rutherford Dickinson, trading as D. H. Engineering Company), 60½, Windus Road, Stoke Newington, has been adjudicated bankrupt.

CRITTALL EXPANDED METAL COMPANY, LIMITED.—It has been resolved and confirmed that the company be wound up voluntarily. Mr. F. H. Crittall, 246, High Holborn, W.C., has been appointed liquidator.

CLEGG FOUNDRY COMPANY, LIMITED.—It has been resolved that the company go into voluntary liquidation. Mr. S. Laycock, Barclay's Bank Chambers, Keighley, L.A., has been appointed liquidator.

MR. F. COMLEY, 30, Thomas Street, Lees, trading as F. Comley, at Prudential Buildings, Union Street, Oldham, iron and steel merchant, and as Comley, Pickard & Company, at 70, George Street, Oldham, engineering specialist, has been adjudicated bankrupt.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Liquid Contraction.

To the Editor of The Foundry Trade Journal.

With reference to the Paper on "Liquid Contraction" by Mr. Buchanan in your issue of May 3, may I point out one or two statements which merit explanation and criticism?

On page 360, column 2, Mr. Buchanan states that "Iron in the ladle . . . is of a higher specific gravity than the iron was before it was melted," and in a sentence below he states as a proof of this the well-known fact that cold metal floats on the surface of liquid metal.

May I point out that the most likely cause of the floating of the solid iron on the surface of liquid iron is that the surface tension of the liquid metal is sufficient to support a certain weight of cold metal, and does not depend on the necessarily small difference in specific gravity that may exist between that of the metal in the two states?

Further, with regard to the statement quoted above, it seems to me that although Mr. Buchanan's principal theme is "Liquid Contraction," he has not applied that phenomenon at all when discussing the difference in specific gravities of iron. Cold metal expands with rise of temperature, and therefore its specific gravity at a high temperature must necessarily be less than at normal temperatures, and also when molten metal solidifies it contracts; therefore, as a natural outcome of these two facts it must follow that the specific gravity of molten iron is less than that of iron in the solid state, which is entirely contrary to Mr. Buchanan's statement.

With regard to the statement that "when iron is molten and in the ladle all the carbon is in the combined form," may I suggest that the "carbide" theory has not yet been proved, and in the light of present-day knowledge from the practical point of view, which goes to show that carbon is probably rather in the state of solution than combination, such a dogmatic statement on a highly controversial subject is apt to be rather unwise?—Yours, etc.,

M. Met.

"A New Bronze Alloy."

To the Editor of The Foundry Trade Journal.

Sir,—I cannot recollect having ever read a column, outside the daily Press, which contained so many loose and in many cases absurd statements as that describing the new bronze alloy in the May 3 issue of your Journal, page 359, which outlined the essentials of a Paper read before the Cleveland Institute of Engineers.

May I crave your indulgence to enumerate a tithe of them?

To say in A.D. 1923 that an alloy contains no crystal boundaries "so wholly homogeneous was the condition," etc., passes far outside the pale of reasoned criticism.

What black magic must lie behind the cryptic statement that the "constituents were combined to form a single solid solution"?

The melting point of 1,100 deg. C. is approximately 150 deg. C. wrong. The melting point of an alloy containing 80 per cent. copper, 15 per cent. zinc and 5 per cent. tin is 940 to 950 deg. C.

An alloy of this composition would also have its physical properties seriously modified by any annealing treatment.

To say that this alloy has an electrical resistance much higher than that of any other copper alloy shows a complete ignorance of the fundamentals of physical metallurgy.

A non-ferrous alloy of this description cannot possibly have a co-efficient of expansion of a similar character to cast iron.—Yours, etc.,

Francis W. Rowe.

Research Laboratory, Mather & Platt, Limited. Manchester.

May 7.

Foundry Apprentices.

To the Editor of The Foundry Trade Journal.

Sir,—Your issue of April 19 contained the valedictory address by Mr. W. T. Evans to the East Midland Branch of the Institution of British Foundrymen, on which I should like to make some comments.

Mr. Evans mentioned the problem of training apprentices, and stated that *no* satisfactory solution was in sight.

I draw Mr. Evans' attention to the Junior Section of the Institution of British Foundrymen formed in Newcastle for moulders, patternmakers and chemists.

This Section aims at the promotion of a better understanding, both socially and at work, between the above-mentioned members of the foundry industry.

Meetings are held at which Papers are read by *members* on moulding, patternmaking, and laboratory work. Works visits, social functions, and the formation of a technical library are also taking place.

It is hoped, in the near future, to hold examinations in efficiency of work and knowledge of that work, as suggested in the inaugural address. Those obtaining over a certain percentage of marks to receive a certificate. This would create an objective for every boy to work for.

I would suggest that this will, if supported by the foundry industry generally, go a long way towards solving this much-discussed problem.—Yours, etc.,

Herbert F. Clements,
President of the Junior Section of Foundrymen, Newcastle.
14, Rosebery Crescent, Jesmond, Newcastle-on-Tyne.

Stanton Iron Works Visited.

Last Saturday a representative party from the London Branch of the Institute of British Foundrymen visited the Stanton Iron Works. The party were first shown the manufacture of concrete pipes by the spinning process, which so largely eliminates the water, that the drying operation is reduced to hours in place of weeks.

The centrifugal manufacture of cast-iron pipes was then shown, the time taken being exactly one minute for each pipe. Owing to the increased strength of the iron, the section of the pipe can be reduced 25 per cent., and twice the standard pressure test maintained. After lunch, at which Mr. Fox gave a hearty welcome to the guests, the very extensive and modern welfare department was inspected.

In thanking the firm and its officials for the hospitality shown, Mr. V. C. Faulkner (president-elect of the Branch) remarked that the firm had acquired a national reputation with foundrymen, as they had recently entertained the Lancashire, Sheffield and East Midlands Branches. He complimented the firm on the initiative they had shown in producing cast-iron pipes showing 18 to 20 tons per sq. in. tensile by the centrifugal plant. They were certainly the pioneers for this particular industry. The firm's welfare arrangements were second to none in the country, and on this too the management were to be complimented.

Cars were placed at the disposal of the visitors for the return journey to Nottingham.

Members of the Institute of British Foundrymen will be sorry to learn that Mr. W. G. Hollinworth, the general secretary, is at present confined to his room with a severe chill. He hopes to return to business in about a week's time.

Messrs. Alfred Herbert, Limited, of Coventry, have appointed The Wellman Smith Owen Engineering Corporation, Limited, 36/38, Kingsway, London, W.C.2, sole concessionaires for the United Kingdom for the sale of the "Atritor" Fuel Drying and Pulverising Machine, for use with metallurgical furnaces.

Magnesium and its Alloys.

By H. J. Maybrey.

Magnesium is the lightest commercial metal, and it is interesting to compare its properties with those of the next lightest commercial metal, namely, aluminium. This is done in Table I.

Table I.—A Comparison of the Properties of Magnesium and Aluminium.

	Magnesium.	Aluminium.
Melting point	651°C.	657°C.
Specific gravity	1.74	2.70
Thermal conductivity	0.38 C.G.S. units	0.49 C.G.S. units
Electrical conductivity	23 reciprocal ohms per cc.	33 reciprocal ohms per cc.
Coefficient of expansion	0.000025	0.000025
Specific heat	0.246	0.21
Tensile strength	7.5 tons per sq. in.	5.5 tons per sq. in.

Chemical Properties.

MAGNESIUM.
Unattacked by alkaline solutions.
Attacked by all acids.
Rapidly attacked by saline solutions.
Burns freely in air if heated much above its melting point.

ALUMINIUM.
Rapidly attacked by alkaline solutions.
Unattacked by nitric acid.
Slowly attacked by saline solutions.
Oxidises slowly in air at its melting point, but rapidly as the temperature is raised.

A study of these tables of comparison makes several facts evident.

Firstly, the extraordinary lightness of the metal. Secondly, that care will be necessary with the metal in the foundry owing to rapid oxidation in the molten state. Thirdly, that, for equal weights, magnesium is in no way inferior—in fact, slightly superior—to aluminium as a conductor of heat and electricity.

Commercial Employment.

The manufacturer is likely to ask in what ways he can make use of this metal. He may be an iron and steel founder, a brass founder, or a light alloy founder.

Steel Foundry.

Magnesium has been used quite extensively as a deoxidiser for steel, and has in many cases superseded the use of aluminium for this purpose. Much investigation has been undertaken in this direction, but not many of the results published. A study of methods of its introduction would probably be profitable by steelworks managers.

Brass-Melting Practice.

A great deal of magnesium is in use among brassfounders as a "scavenger." It is introduced into the molten metal in two ways. Either, as a pure metal, it is pushed to the bottom of the melt underneath a small inverted clay crucible attached to a stirring rod, or, in the form of a brittle alloy with 50 per cent. of copper, it is stirred into the molten metal. The amount of magnesium added depends on the amount of "scavenging" that is required. An ounce of pure magnesium (or two ounces of the 50:50 alloy) to a hundredweight of molten metal is an average charge. Too much magnesium tends to make the resultant casting brittle and hard.

Use in Conjunction with Aluminium.

The aluminium founder uses magnesium in making up several well-known alloys. "Magnalium" is a name familiar to most foundrymen. It is a name for a range of alloys containing from 2 to 10 per cent. of magnesium added to aluminium. These alloys are lighter than pure aluminium. They have a maximum tensile strength of 11 tons per sq. in., with an elongation of 5 per cent. In the alloy 6 per cent. of magnesium is added. The alloy containing 2 per cent. of magnesium, is more ductile, and is one largely employed for rolling.

An alloy containing 50 per cent. each of aluminium and magnesium is very brittle and hard. It has the unusual property of expanding on solidifying. It is very easily powdered, and is largely used as a scavenger for aluminium and aluminium alloys.

Special Alloys.

The well-known "Y" alloy and "Duralumin" alloy both contain, as an essential constituent, about 1½ per cent. of magnesium.

In recent years the light alloys founder has been inclined to regard magnesium from another point of view, as the main constituent of light alloys. At first the lightness alone intrigued the manufacturer. Recently the high thermal and electrical conductivities of magnesium and some of its alloys have been great factors in furthering this interest. In Germany, during the war, owing to the scarcity of copper, magnesium was very largely used to conduct electricity.

From a commercial point of view, the steady fall in price of the pure metal produced by the wonderfully efficient Ashcroft process is of great interest. With such a process, and the enormous supplies of raw materials, it requires only a rather larger demand than the present to bring the price of the metal down to a very low figure. Considering that the metal is more than four times lighter than cast iron, many possibilities are apparent.

Other Alloys.

The results of the investigation which has been the outcome of this interest on the part of manufacturers have brought to notice many interesting magnesium alloys. These alloys have been developed by those same painstaking researches and systematic methods which have characterised the development of any new scientific industry.

The properties of magnesium alloyed with aluminium, zinc, copper, nickel, cadmium, tin and many of the lesser known metals have been determined with diverse ideas in mind. In general, some alloys were desired for "casting" and some for "working" purposes.

In the former class a great deal of work has been undertaken with an idea of obtaining an alloy suitable for use in making pistons for internal-combustion engines.

Automobile Requirements.

Automobile engineers require that the ideal material for this work should have the following conditions observed:—

(1) The metal must be light and strong. The strength must not fall unduly with such rises of temperature likely to be found in any ordinary engine.

(2) The metal should have "hardness" to withstand abrasion.

(3) The thermal conductivity of the metal should be as high as possible.

(4) Its co-efficient of expansion should be low.

(5) It should not "grow" in use.

(6) The machining properties of the metal must be good.

(7) Unreasonable complication in handling the metal in the foundry must be avoided.

(8) The metal must be reasonably cheap.

It must be admitted that no one single metal or alloy is likely to fulfil all these conditions to the utmost. It can be claimed that certain magnesium alloys more nearly approach the ideal than any other known metal or alloy.

The magnesium alloy containing 13 per cent. of copper has a density of 1.90 and a tensile strength of 8 tons per sq. in. at ordinary atmospheric temperatures. This strength decreases to 4½ tons at 350 deg. C., which is a favourable comparison with the aluminium alloys employed for this purpose. The Brinell hardness number is 61. At 100 deg. C. the thermal conductivity is 0.32 c.g.s. units; at 350 deg. C. this figure *increases* to 0.34. There is a material decrease in the conductivity of cast iron (which is only 0.11 at 100 deg. C.). Comment is, over this range of temperature, perhaps superfluous.

The co-efficient of linear expansion of this alloy is nearly the same as the pure metal, viz., 0.000025, a very similar figure to that obtained for aluminium piston alloys. However, *magnesium pistons do not "grow"* in use. This "growth" has been a great drawback to aluminium pistons, and its absence is a very important point in favour of magnesium alloys. Very little more clearance than cast-iron pistons demand is required for magnesium pistons, since the growth has not to be

allowed for. Consequently, the slap and incidental troubles typical of aluminium pistons are absent.

The machining properties of all the magnesium alloys are excellent, and, compared with aluminium alloys, remarkable. In passing, it should be mentioned that collections of fine turnings should not be allowed to accumulate; if this simple piece of advice is followed the dangers of turning magnesium disappear.

The cost of magnesium alloys depends upon the cost of magnesium, and this matter has been referred to already.

Practical Considerations.

If the few directions given here are followed and ordinary common sense exercised, sound castings in this and other magnesium alloys may be obtained with no unreasonable elaboration.

Firstly, it is advisable to melt magnesium and its alloys in cast-steel pots. If ordinary fireclay pots are used the metal will become contaminated with much silicon. A little of the pure metal (or alloy previously made up) should be melted in the bottom of the pot. The lid should be kept on top of the pot to prevent the free access of air to the melting metal. When the molten metal is a few degrees above the melting point, small pieces of cold metal should be added in such a manner that there is always a little undissolved metal in the pot. This keeps the temperature of the melt low.

If it is desired to make up an alloy, the pure metal should be melted as above, and the other constituents added either as pure metals or rich alloys at the end. It is strongly to be urged that a pyrometer is used in making up alloys.

Before casting, the pot should be removed from the furnace, the melt skimmed free of oxide and nitride, and cast immediately afterwards.

These skimmings should be dropped on to a clean, cold iron plate, and pressed down with another cold iron. This prevents them burning away.

The metal is cast into chill or sand moulds. After experiment, great success has been obtained using chill permanent moulds. It is to be remembered that magnesium alloys require much more head than aluminium alloys to produce the same pressure. About half as much again is needed.

Before casting in sand moulds it is necessary to be sure that the moulds and cores are baked *bone dry*, to obtain satisfactory results. The metal should be poured into the moulds as soon as these are removed from the oven, as otherwise during cooling the sand will reabsorb moisture, and time and effort will be wasted.

The gates used in making up these moulds should be as short as possible and only just large enough to allow a free flow of metal.

The chief properties of the 13 per cent. copper alloy have been given. This alloy is strongly to be recommended for piston manufacture, though sometimes alloys containing from 6 to 11 per cent. of aluminium are used for the purpose. The thermal conductivities of these latter alloys are, however, considerably lower than that of the copper alloy. Nevertheless, the 6 per cent. aluminium alloy has a tensile strength of 11 tons per sq. in. and an elongation of 7 per cent. Its Brinell hardness number is 52. The 11 per cent. aluminium alloy has the higher Brinell number of 65, but its strength, 8 tons to the sq. in., is not as high.

Magnesium alloys can be rolled, extruded, drawn, forged into any desired shape. For such purposes a suitable alloy is one containing magnesium alloyed with 1 per cent. of cadium. This alloy has a tensile strength of 12 tons per sq. in. and an elongation of 14 per cent. With rolling the tensile strength can be increased to 23 tons per sq. in. with a decreased ductility.

The magnesium-nickel alloys show great strength and hardness and are being investigated at present. Both in this country and in the United States work is being done on the heat treatment of magnesium alloys.

To sum up, it is possible to make magnesium alloys which are light, strong and ductile with which it is well to get acquainted, as daily they are coming into more general use. As the demand lowers the price the rate of increase of their applications will become more rapid

"Moulders" of the Industry.

No. 2.—MR. CAREY HILL.

Mr. Eustace Carey Hill was born in Coventry in 1882 of a family of watch manufacturers long established in that city. He was educated at Oundle School, taking advantage of the special facilities provided there for studying engineering. He continued these studies in the works of the Beeston Motor Company, Limited, and of the Daimler Motor Company, Limited, in Coventry, and at the Technical Schools of Coventry and Birmingham. He entered the foundry and general engineering business of his father, Mr. Rowland Hill, J.P., at the end of 1902. This business was formed into a limited company in 1908 as Messrs. Rowland Hill & Sons, Limited, to continue the manufacture and supply of aluminium castings to the motor car and engineering trades, since which date he has occupied the position of technical director and works manger.

He served in the Imperial Yeomanry in the South African War in 1901 and 1902 (medal and five clasps).

Mr. Carey Hill.

He is a member of the Institute of Metals, and of the Birmingham Metallurgical Society, a member of Council of the British Non-Ferrous Metals Research Association, Past-President of the Coventry Branch of the Institute of British Foundrymen, and Vice-President of the Coventry Engineering Society.

He is the author of the following Papers:—"Aluminium: Its Use in the Motor Industry" (Coventry Engineering Society); "Aluminium Alloys in the Foundry" (Coventry Branch, I.B.F.); "Some Details in Foundry Management" (Presidential address, Coventry Branch of the I.B.F. during the session 1921-1922).

Other interests:—He is Past-President of the Coventry Natural History and Scientific Society, member of Committee of the Coventry Branch of the Historical Association, member of the Birmingham Archæological Society, and Hon. Treasurer of the Coventry Guild for the Preservation of Ancient Buildings, etc., and the author of a Paper on the Origin and Probable History of "Brinklow Earthworks," Warwickshire, read before the Coventry Historical Association. He is a member of the Foundry Sub-Committee of the Coventry Engineering Employers' Association, and of the National Foundry Technical Committee (Non-Ferrous Metals) of the National and Engineering Employers' Federations. He also represents his firm as member of the British Refractories Research Association. He was married in 1911. Residence: The Hollies, Kenilworth.

Mr. Ivor Jones, iron merchant, of Middlesbrough, is at present in Stockton Hospital as the result of a motor accident.

The Shrinkage of Metals.*

By F. Johnson, D.Sc., M.I.Brit.F.

It is unfortunate that considerable confusion exists regarding the definition of the term shrinkage. Shrinkage and contraction are synonymous terms, and little success can attend the efforts which have been made to confine either of these to denote the volume change accompanying the passage of a metal from the liquid to the solid state, whilst restricting the other to the volume change which occurs in a solid metal when cooling from the freezing-point.

The terms should be interchangeable, and, to differentiate between the various physical states of a metal, a little more extensive use should be made of our vocabulary than some previous investigators have been willing to make.

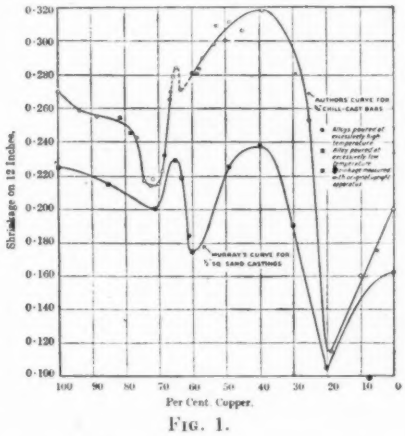

FIG. 1.

With one or two notable exceptions, a metal shrinks in volume with fall in temperature in three distinct states: (1) In the liquid state; (2) in the liquid and solid state; (3) in the solid state. Shrinkage can therefore be classified into three stages, viz.: (1) Liquid shrinkage (or contraction). (2) Solidification shrinkage (or freezing). (3) Solid shrinkage.

The shrinkage in (1) and (3) will be uniform in rate and in direction, although there is possibly a different coefficient for liquid from that for solid metal. In (2), however, the conditions are very different from (1) and (3), as the metal is undergoing a change of density with change of state, and for the freezing interval the rate of shrinkage will be far greater than for any similar temperature interval either above or below the freezing point.

It is clear that the higher the temperature at which a metal enters the mould, the greater will be its liquid shrinkage from its temperature at entrance to its temperature at freezing point. It therefore follows that the amount by which a solid casting fails to fill an open mould will increase with the pouring temperature.

It does not follow, however, as Anderson states, that "the linear contraction of a metal or alloy on pouring into a mould is a function of the pouring temperature." Although it is true that less metal by weight can be put in a mould cavity of a given size at a higher temperature than at a lower one, the linear contraction is not affected by pouring temperature, *qua* temperature, as the outer shell or crust which forms against the walls of the mould must be always of the same dimensions, since for a given metal and thickness of crust it must always form at the same temperature. If liquid shrinkage were responsible for the metal contracting away from the walls of the mould before the outer crust formed, then Anderson's statement would be correct, but such cannot be the case, for hydrostatic pressure keeps the shrinking liquid in contact with the walls of the mould until the outer crust does form. Thus it is difficult to see how the measurable linear contraction can be affected by pouring temperature, except indirectly.

Consequences of Shrinkage.

The shrinkage which metal undergoes in passing from the liquid state to the solid state at normal temperature is responsible for no small part of the troubles experienced by the foundryman. It affects him in three vital ways, as shown under the following headings:—

(1) By entailing considerable expenditure of time, skill, labour, and material in the preparation of master patterns.

(2) By necessitating the provision of gates for feeding purposes.

(3) By creating internal stresses in castings owing to differential rates of cooling for different sections, often resulting in fracture.

Under heading (1) much economy can be effected by ascertaining the precise amount of shrinkage which any given metal or alloy will undergo. If this information be not available, it may be necessary to make many alterations to the wooden pattern until it is possible to obtain a metal pattern from which castings of the required size may be obtained. Very meagre data are available under this head, and such figures as are published are incorrect or correct only for the special conditions under which they were obtained, and therefore not applicable to all foundry conditions.

The curves shown in Fig. 1 for the shrinkage of the copper-zinc alloys indicate the folly of applying one value only for "brass."

Anderson states that, of all the factors which are responsible for variations in shrinkage of any given alloy, the two most important are pouring temperature and size of section.

There appears, therefore, to be a real need for extensive research on the shrinkage behaviour of the many commercial alloys in use under a wide range of conditions. Failing that, it would be desirable for every foundry to have its own instrument for measuring shrinkage, and to make liberal use of it in order to obtain shrinkage data of the alloys in which a foundry specialises under the range of working conditions which obtain therein.

Under heading (2) there would appear to be little scope for economy. Shrinkage is a natural

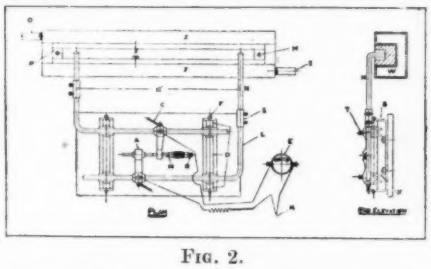

FIG. 2.

phenomenon which cannot be suppressed; hence there will always be the need for providing for the adequate feeding of section by section and of casting by gate or riser. Thus much labour is entailed, scrap metal produced, and time lost in the designing, moulding, and removal of gates and risers.

Under heading (3) there is much scope for ingenuity in design of castings, in arrangement of such matters as the determination of camber, in the provision of chills, in prompt stripping of heavy sections, and in methods of moulding, so as to minimise internal strains or mitigate their destructive influence. Most castings can be improved by some form of annealing, so carried out as to remove the internal stresses, the retention of which might result in weakness or even rupture. These stresses are produced by differential rates of cooling in thick and thin sections of a given casting, or even in a casting of uniform section. Different parts of a casting cooling at unequal rates must inevitably shrink at different rates, and the part which shrinks the faster imposes on

* A paper presented to the East Midlands Branch of the I.B.F., Mr. W. T. Evans presiding.

another part a stress to which that part may or may not be able to accommodate itself. In the former case, the metal is able to yield either elastically or plastically, residual stresses remaining in the casting. In the latter case the stress imposed by shrinkage exceeds the maximum stress which the part affected is capable of sustaining and fracture takes place.

Some mixtures of cast iron and other brittle alloys may fracture in the mould or may be so fragile under the influence of internal stresses that a slight jar will cause them to break when removed from the mould. Such alloys or even less brittle alloys call for ingenuity in the provision of cores (where such are necessary) of the correct constitution. The cores must be so constituted that they will offer little or no resistance to the crushing action of the shrinking metal by which they are enveloped.* They may be rendered collapsible by reason of the combustible or friable nature of the binder used, or by the ability to yield of a specially inserted material, such as straw or ashes. Hard, unyielding cores are frequently the cause of cracking in castings, the inevitable shrinkage of which cannot be resisted with impunity.

Theory of Angular Weakness Explained.

The stresses imposed by shrinkage are so great that special care must be exercised in designing castings so that no places are left vulnerable to their influence. Take, for instance, castings with a sharp re-entrant angle. Isothermals, or lines of equal temperature during solidification of the casting, would curve inwards towards the core, owing to the heat lost by one of the limbs. Therefore, at any moment during solidification the metal in the neighbourhood of the re-entrant angle will be at a higher temperature, and therefore weaker, than the metal of the limbs. The latter shrink as they cool and naturally tend to shrink away from each other, thus imposing a stress on the metal at the angle, which, being weaker by reason of its higher temperature, may either fracture or be left in a dangerously-stressed condition. There may even be formed a minute pipe or shrinkage cavity at the bend, which would aggravate the weakness, whilst further aggravation might be expected from the segregation, in large castings, of a fusible constituent which at any given moment would be weaker than the metal from which it had segregated. The possibility of gases being liberated in excess at the bend has also to be taken into consideration. Thus, the old idea is no longer tenable that weakness in castings having sharp angles is due to the mode of crystallisation whereby a plane is created along which a succession of terminal faces of one set of ingrowing crystals meets a succession of similar faces of another set of crystals growing in a direction at right angles to the first set. As Rosenhain points out, intercrystalline boundaries, assuming they are not separated from one another by films of a brittle constituent, are planes of strength rather than planes of weakness.

Apart from sharp-angled corners, there is the question of change of section. One would expect to find that in castings in which thick and thin sections are "tied" to each other, the latter will, unless special measures be taken, cool in advance of the former. The thin sections will, therefore, as in the case of a grid surrounded by a heavy rim, contract faster than, and exert an inward pull on, the thick section which will be in tension, whilst they themselves will be in compression. Where the compression strength of a metal like cast iron is greatly in excess of its tensile strength, the ratio of cross-sectional areas thick to thin will always have to be greater than the ratio

$$\frac{\text{Maximum compressive strength}}{\text{Maximum tensile strength}}$$

of the material in order that failure by fracture (should any occur) may take place in the thin section. In practice this sectional ratio is scarcely, if ever, obtained, so that when such castings fail, the fracture will be found in the thick section, as the result of its inability to withstand the tensile stress imposed and the fractured ends will spring apart. Conversely, if the thin section of a perfect casting be purposely broken, the fact that such section has been in compression will be shown by the fractured ends overlapping.*

The phenomenon of shrinkage is not always a simple matter of diminution of volume at a uniform rate, but may be complicated by arrests or even positive expansions either during or after solidification. So far as is known, bismuth is the only pure metal which expands during solidification, and actually occupies a larger volume immediately after than immediately before solidification. Its temperature of maximum density is said to be like that of water just above its freezing point. Keep, Turner, and Wüst, among others, have investigated the volume changes of cast iron and other metals and alloys, during and after solidification, and have found that profoundly important volume changes occur other than the diminution of volume due to change of density. Professor Turner has recorded that white iron undergoes a small expansion at about 700 deg. C., corresponding with the formation of pearlite, whilst grey phosphoric iron undergoes three very marked expansions, due to separation of primary graphite, of the phosphide eutectic, and of secondary graphite respectively. "These expansions correspond with definite alterations in density and physical properties in the casting. They also account for many of the fractured castings which are met with in practice, especially such as are due to faulty design." C. Heggie has applied this knowledge to thick and thin bars, and has shown that bars of ½-in. square section will have completed their expansions and have commenced to contract uniformly before 1-in. square bars have completed their first expansion. Thus in a given casting sections of ½-in. sq. will be contracting in one direction, whilst sections of 1-in. sq. will be expanding in another direction. Thus in the limbs of a casting connecting two such different sections, dangerous internal stresses will be set up in addition to those created by the subsequent differential shrinkage rates of those sections.

It must not be forgotten that the physico-chemical changes to which these so-called expansions correspond are accompanied by evolutions of heat which would in themselves account for retardations in the rate of cooling, quite sufficient to aggravate the internally-stressed condition of the casting. Wüst found that alloys consisting of aggregates, e.g., Pb-Sb, shrink less than their components, whilst solid solutions, e.g., brasses and bronzes, shrink more.

Professor Turner states that, as the results of shrinkage tests on non-ferrous metals and alloys (using Keep's test), the shrinkage of alloys was usually less than the mean shrinkage of the constituents, and that the result obtained varied somewhat with the thickness of the bar (rate of cooling).† In extensometer tests, *pure metals* could not be said to show expansions, and the influence of the internal pressure created by gas bubbles is admitted. Yet Ewen found expansions for pure Al, Zn, and Sb.

Solid Solutions.

In examining a series of solid solutions, however, definite and well-marked expansions were obtained, these appearing to vary in magnitude with variation in magnitude of the crystallisation interval. Results obtained in Professor Turner's laboratory indicate that alloys of the copper-zinc series which show zero expansions with the extensometer, have densities furthest above the theoretical density and those showing well-marked expansions have densities furthest below the theoretical density.

Another very interesting discovery is the behaviour of *eutectic alloys*,‡ which appear to show a maximum on an expansion-composition curve. This receives support from Wüst, who expresses it in a different way, viz., that the eutectic has a minimum shrinkage.

* "Journ. Inst. Met.," Vol. XIII., p. 366.

* C. Heggie, "Proc Inst. Brit. Foundrymen," 1914-1915; A. Frazer, "Proc. Inst. Brit. Foundrymen," 1919-1920.

† Ewen and Turner, "Journ. Inst. Met.," No. 2, 1910.

‡ H. von Miller states that the shrinkage of 92 Cu :8 Sn bronze is not appreciably lessened by zinc up to 10 per cent., whilst Al, Fe, Ni, Co and Si increase the shrinkage.

With regard to *inter-metallic compounds*, Haughton* supposes that a compound, e.g., Cu_3Sn, *should* show a minimum expansion, and refers to a similar minimum for the compound Cu_2Zn_3, found by Murray. Such expansions or retardations as do occur in the freezing and cooling of alloys are (excluding extraneous influences such as gas occlusion) associated with physico-chemical reactions or phase-changes, and therefore reference may be profitably made to the diagrams of thermal equilibrium for their explanation. They are certainly important to foundrymen in their influence on total linear shrinkage and in thus affecting the allowance which must be made in the pattern.

Effect of Various Factors on Total Shrinkage.

Anderson enumerates the most important factors affecting the shrinkage of cast alloys as follows, viz.:. (1) Chemical composition. (2) Pouring temperature. (3) Cross section of the casting. (4) Ratio of the length to the cross-sectional area. (5) Character of mould and method of moulding. (6) Gas-occlusion and overheating of the molten metal.

Chemical Composition.

It is obvious that components of different shrinkage values will produce an alloy whose shrinkage value will differ from those of the separate components. There appears to be no definite rule from which the shrinkage of an alloy of any composition could be predicted from a knowledge of the shrinkage behaviour of the components. It often happens that the total shrinkage of an alloy is in excess of the mean of the values obtained for the components, that is to say, alloying is often responsible for a specific addition to the total shrinkage, although in some cases it may even be responsible for a specific diminution in the total shrinkage. Take, for instance, the low shrinkage and specific gravity of the alloy copper 10, zinc 90, and also the claim made by Wüst for the absence of shrinkage of the alloy (Bi 49.88 per cent., Pb 32.47 per cent., Sn 17.38 per cent.)†. Relatively small changes of composition sometimes account for big changes in shrinkage, e.g., the 60: 40 and 70: 30 Cu-Zn alloys.

An alteration in *constitution* of the alloy may be due to changes in composition so slight as to be incapable in themselves of affecting the amount of shrinkage.

It may be a constitutional change so great as to bring about a very great alteration in shrinkage, e.g., the conversion of white iron to grey by the slight modification in the sulphur and silicon content. As is well known, the shrinkage allowances for white-iron castings are much more than for grey iron.

Pouring Temperature and Shrinkage.

As already pointed out, the author is not prepared to admit that even theoretically a casting poured at a high temperature should undergo less total linear shrinkage when properly fed than when poured at a low temperature.

It frequently happens that, owing to greater quantities of gas being dissolved at higher temperatures, the total shrinkage will be less and not more than at lower temperatures. This is because a larger amount of gas is liberated at the solidification stage, and the expansion of the gas-bubbles opposes the natural shrinkage of the metal. Anderson states that castings poured at intermediate temperatures shrink more than those at higher or lower temperatures. No figures are given, but the lower shrinkage of the latter must be due to the castings being "short-run." The same author discounts his statement by suggesting that a high pouring temperature, in causing a slower rate of cooling than a low temperature, thereby causes a smaller shrinkage.

This statement is confined to those alloys having "a *time* interval of freezing." Which alloys have not? Anderson probably means a *temperature*-interval, which indicates a range of fusibility during solidification, and doubtless the slower rate of cooling during solidification would result in better internal feeding, and thus a casting freer from microscopic shrinkage-cavities and of greater, not less, shrinkage, should be obtained. It is not obvious to the author that a slowly-cooled casting should have less shrinkage than a rapidly-cooled one.

J. D. Edwards and H. T. Gammon have recently investigated the relationships between shrinkage and piping in aluminium and its light alloys with copper. The total shrinkage of the pure metal and of alloys containing 4 and 8 per cent. copper is practically the same. The volume of the pipe is not, however, necessarily equal to, nor proportional to, the solidification-shrinkage. In the case of the pure metal the two are very nearly equal, but in the case of the alloys the volume of the pipe is less, whilst the solidification-shrinkage is greater.

The data were obtained by pouring the molten metal into a graphite crucible of known capacity, slightly over-filling and pressing off the excess by means of a hot iron plate. In the pure aluminium ingot, the solidification-shrinkage is represented by the volume of the pipe, but in the 8 per cent. alloy it is not adequately so represented. This is attributed to the difference in rigidity of the outer shells formed at the commencement of solidification. In the pure metal this shell is quite solid and rigid, and during the freezing process retains its position, but in the alloy the shell consists of a mixture of a solid skeleton of solid solution, with liquid eutectic interspersed in the interdendritic spaces; it is therefore of a "mushy" or plastic nature, and settles down in the mould. This action is facilitated by the longer interval which elapses from the commencement of freezing of the primary crystals to the freezing of the eutectic. As a consequence space in the ingot which would otherwise have been occupied by pipe is occupied by metal and the pipe is proportionately smaller.

The shorter length of the alloy ingot is all the more striking when it is considered that the *solid* shrinkage of the alloy from the completion of freezing to normal temperature is less than that of the pure metal.

The good casting properties of the 8 per cent. alloy are ascribed partly to this mechanism of freezing, for shrinkage stresses will be accommodated by the plastic condition of the metal and the cores and other fragile parts of the mould will be relieved therefrom. The lower solid shrinkage of the alloy is again a point in its favour, since the lower this is the fewer the internal strains set up in the casting.

In a paper* by J. D. Edwards, he showed that there is a linear relationship between the composition and specific volume of copper-aluminium alloys in spite of the existence of intermetallic compounds $CuAl_2$ and Cu_9Al. From a linear relationship of this kind the approximate specific volumes and therefore the densities of the solid alloys at temperatures up to their melting points can be calculated.

The densities of the liquid alloys at various temperatures have been determined by the same author† by means of a densimeter.

Use of Equilibrium Diagram.

From the equilibrium diagram the relative proportions of solid and liquid can be obtained, and thus the densities, during the freezing interval, of solid and liquid in equilibrium with each other at any temperature can be ascertained. The data when plotted reveal some very interesting and important facts. The first of these is that the first crystals to separate from the liquid (*i.e.*, up to a proportion of 25 per cent.) are heavier than the liquid by reason of the usual increase in density accompanying the change liquid to solid. When one-quarter of the alloy is solid the densities of solid and liquid are the same, owing to the fact that the primary crystals separating have been rich in the lighter metal aluminium, whilst the liquid has been concentrating in the heavier metal copper. When more than ¼ of the alloy has solidified, the crystals are now lighter than the liquid. Thus there are three stages as follows:—

* "Journ. Inst. Met.," No. 2, 1911, p. 203.

† "Metallurgie," 1909, Vol. VI., pp. 769-792. This alloy is said to expand during cooling, so that the bar finally obtained is 0.3 per cent. longer than the pattern.

* "Mechanism of Solidification of a Copper-Aluminium Alloy," J. D. Edwards, "Chem. and Met.," Eng. g., Vol. 24, 1921, p. 215.

† "Ibid," 24, 1921, 61.

(1) When ratio $\frac{\text{solid}}{\text{liquid}} < \frac{1}{4}$ the solid crystals will sink in the liquid.

(2) When ratio $\frac{\text{solid}}{\text{liquid}} = \frac{1}{4}$, the densities of solid and liquid are the same.

(3) When ratio $\frac{\text{solid}}{\text{liquid}} > \frac{1}{4}$, the solid crystals will rise.

The effect of the first stage on the final condition of the casting is not quite apparent, but the last stage will be characterised by the upward segregation of aluminium-rich crystals and a downward segregation of copper-rich liquid. Apart from the lack of uniformity of composition and properties resulting from such segregation, the mechanism of shrinkage will be affected by the bridging over of the higher-freezing-point crystals at the top of a casting, leaving the inter-skeletal liquid to gravitate downwards as the lower part of the casting solidifies and shrinks. Thus there will be a porous, crystalline, spongy area at the top, with possibly a pipe or large shrinkage cavity underneath. This probably accounts for the practice of bringing gates in at the lower part of a casting, so as to ensure adequate feeding, which would be prevented in the case of top-gating by the formation of the "clot" of specifically-lighter crystals which would obstruct the passage of liquid metal from gate to casting.

Shrinkage Apparatus described.

In conclusion, the lecturer drew attention to a number of methods which have been employed for determining total linear shrinkage of metals. The apparatus, designed by himself and recently used for the determination of shrinkage of copper-zinc alloys, was described in detail as follows:—

Referring to Fig. 2, it will be seen that the apparatus consists of a micrometer, the head of which is separated from the anvil. Both head and anvil are fixed each to a steel socket *A*, provided with a tightening clamp *C*, which clamps securely to a moving arm *L*.

The two arms are guided by the grooved vulcanite wheels *V*, which rotate freely on the stationary spindles *F*, fixed in rigid supports *B*. Parallelism of the two micrometer arms was ensured by placing distance pieces *D* between the grooved wheels.

Each micrometer arm is bent through an angle of 90 deg. in a horizontal plane, and a sleeve *S* is fixed at the end of each by means of a set-pin. Into the free end of each sleeve a detachable extension rod *N* is inserted and tightly gripped by means of a second set-pin. The ends of the extension rods *N* are bent through an angle of 90 deg. in a vertical plane, thus forming the legs, which rest in the mould, the distance between them being regulated by means of a gauge.

It was thought that some degree of error might be introduced by variation in obtaining contact between the micrometer head and anvil. If screwed up with too much pressure, the tendency was to "spring" the arms slightly.

An endeavour was made to obtain a standard contact by electrical means, using the e.m.f. generated in the thermo-couple *K*. Connections were made between the couple wires and a terminal *T* in the anvil, and another terminal in the head of the micrometer.

The millivoltmeter *E* and a resistance were inserted in the circuit, and short-circuiting was prevented by the vulcanite wheels *V* and sleeves *S*.

When the slightest contact was made between the anvil and head of the micrometer, current flowed through the circuit and produced a deflection of the needle of the millivoltmeter, the extent of which could be standardised. The method was not finally adopted as, owing to its great sensitivity, an excessive amount of time was absorbed in obtaining standard deflections.

Moreover, by careful use of the ratchet attachment *R* the error in reading, on making repetitive contact, was found to be negligible. The micrometer was of Brown and Sharpe make, and gave vernier readings to 0.0001 in. It was thought, however, that sufficient accuracy was obtained by reading to 0.001 in., an error of this amount representing from 1 in 120 to 1 in 300.

No attempt was made to magnify the movements of the rods, although this would be an easy matter if greater sensitiveness were required as, for example, in an investigation of changes due to thermal transformations, etc. In such a case it would be desirable to retard and control the rate of cooling in a resistance-wound mould or tube, using a rheostat. The magnification could be effected by pointer or by fixing a wheel on one of the spindles and causing it to engage a friction wheel of larger diameter, suitably provided with a scale.

Wavelength Tables.

The possibilities of the application of "emission spectroscopy" to daily analysis is not fully appreciated in the chemical industry.

It affords a means of solving many a problem not easily tractable by the ordinary chemical analysis.

Every element can be identified by the spectroscope under some condition.

Messrs. Adam Hilger, Ltd., 75a, Camden Road, London, N.W.1, have issued a complete collection of wavelength tables which will prove to be of the greatest value for ordinary use in the laboratory.

It comprises standard wave lengths from 2,375-8,495-I.H., the persistent and sensitive lines of most of the elements being arranged under the name of each element. A list of wave-lengths useful in the determination of stellar-radial velocities are also included.

The value of this book will be better appreciated when it is remembered that the spectroscope affords a simple means of revealing the constituent elements of metals, minerals, refractories, glass and many other substances.

The components of an alloy, for example, are easily discovered, whatever their nature. The elements, which occur in small quantities and impart peculiar properties to the metal, disclose their identity and give some idea of the proportions in which they are present.

The principal advantage of spectrography, however, is in the comparison of the composition of two samples of a similar material exhibiting some differences in their physical properties, and having the same chemical composition as determined by ordinary analysis; when by simple comparison of their two spectra, their elemental differences are at once made evident.

By this method of analysis, one can thus detect the minutest difference of purity in any metal or alloy, and the lines of unsuspected elements will be exhibited with the same regularity as those of the elements which are expected, even in the most complex mixtures. A further advantage of this method of analysis is that very small quantities suffice for examination, and no elaborate preparation is required.

Its value, however, is strictly limited to a qualitative analysis, and there is little hope that it will ever attain that order of precision associated with gravimetric chemical analysis.

Safety First and Foundry Goggles.

We have recently given some prominence to the question of furnace and fettling glasses. Messrs. The Triplex Safety Glass Company, Limited, of 1, Albemarle Street, Piccadilly, noticing this, have sent us specimens of glass goggles, which would certainly give the fullest protection to the men in the fettling shop. A second practical difficulty is overcome by the fact that Triplex glass can be made up to a doctor's prescription. However, the main difficulty of protecting furnacemen's and welders' eyes from dangerous rays still remains to be solved. We presume that once industry decides to adopt a standard tint of definite intensity which will prevent dangerous rays from passing, this glass could be "triplexed" and made safe from flying fragments. Most melters can show a scar due to an idiotic method of smashing a sample on a steel rail or similar bearing, or the burring up of a bar end when negotiating a hard tap hole. From a humanitarian point of view, we do not hesitate to recommend the use of Triplex glass in every fettling shop. If only one eye is saved in the next ten years it is worth it.

An Apprenticeship Course in Foundry Practice.—XLIII.

By Ben Shaw and James Edgar.

PATTERNMAKING MACHINES.

In some trades, machine work has quite superseded hand-labour and the unskilled worker has taken the place of the skilled mechanic. This can never happen in either the foundry or the patternshop, but machining is used in both these shops to-day to an extent undreamt of by the craftsmen of thirty or forty years ago. For a long time the apprentice was discouraged from using the machines in the belief that such knowledge would interfere with his acquisition of skill as a craftsman. Even now in many patternshops the use of the machines by the apprentices is not allowed and this not altogether because of the attendant risks.

The patternmaker differs from other woodworkers in this, that while a carpenter or cabinetmaker has usually a quantity of pieces of the same design to saw at one time, most of the patternmaker's work is of the special cut kind. Further, while it may suit other woodworkers to have material cut to the gauge line or through it, in nearly all cases the patternmaker must have the line preserved. Thus it is desirable in nearly all cases for the patternmaker to do his own machine work. All this may be thought to be outside the scope of a series of articles mainly intended for apprentices and young journeymen, but sufficient emphasis cannot be laid on the necessity for the patternmaker doing his own machine work, because in recent years the custom of employing special men in patternshops who do all the machine work has grown and it has not helped towards efficiency. No wood machinist, who is not a trained craftsman can understand the need for accuracy, and in most cases, where machinists are employed to do patternmakers' machine work there is far more bench work necessary in finishing than there ought to be.

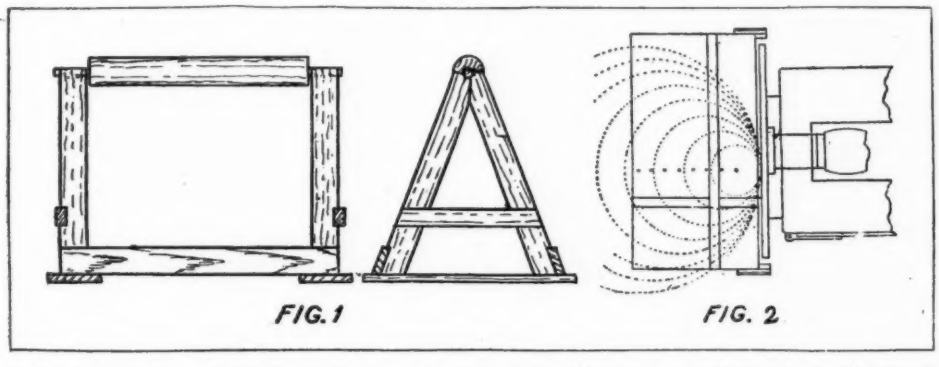

FIG. 1 FIG. 2

For patternmaking, there is no automatic machining. Indeed a great deal of skill is essential to make the greatest possible use of machines. In this and a subsequent article we propose to review in turn the various patternmaking machines and show many practical arrangements for making the machines more useful. If the apprentice observes, he will find that men who use the machines most are the cleverest craftsmen and he will also find that these men generally make the machines do seven-eighths of the hard work. Thus, while their output may be two or three times that of other men, they have a much more comfortable time. It should be an axiom, then, of the apprentice who wishes to excel, never to do an operation with hand tools that a machine will do for him. If he acquires the habit of using the machines whenever possible he will soon acquire skill and confidence in their use, and the man who is confident, without being rash, is in less danger of accident than the less confident and more timid man.

"Safety First" Notions.

Nearly all machine accidents in patternshops are the results of rashness or timidity. The rashness usually takes the form of leaving off fences or guards or neglecting to take some necessary precautions through indolence. Timidity is the result of lack of skill or of not knowing the capacity of a machine. An experienced patternmaker, when he enters a new shop, makes it almost his first business to ascertain the capacities of the various machines. He learns how to start and stop them and also how to adjust them for different purposes. A wood machine is much more sensitive than most metal machines, more easily put out of order and more likely to cause accidents because of the thin cutting edges and the high speeds at which the tools revolve. The apprentice should cultivate the habit of taking no undue risks. "Safety first" should be his motto and he will find that in practically all cases the adoption of safe methods means quicker and better results.

In most patternshops it is one man's duty to attend to the machines. Even in very small shops where only two or three men are employed, it is the usual custom for one man to devote part of his time to sharpening and oiling the various machines. On the other hand, there are shops where tending to the machines is anybody's business. This is not good for the machines. It is very seldom indeed, under such conditions, that the greatest possible use is made of the machines, yet the keen apprentice benefits because he will take the opportunity of learning how to sharpen planing machine irons and how to set and sharpen circular saws.

Trimming Machines.

It is a very small patternshop, indeed, that has not at least one trimming machine. One text book on patternmaking states that bench-trimming machines are sometimes owned by individual workmen, but we have never come across one instance of patternmakers owning their own trimmers. The trimming machine knives must be sharp to do good work. The most important use of the trimmer is when building segments. Some craftsmen trim all the edges of the segments at the machine and afterwards plane them on a shooting-board. If a trimming machine is in good condition, it makes a perfect finish and it should never be necessary to plane edges after being trimmed. The machine should not be given more work to do than can be avoided. If, in the case of segments, the template is made to the finished size not more than 1/16-in. should be left at the bandsaw for finishing. It is sometimes an advantage to clamp a piece of thin timber to the machine-table against which the segments can be pressed when cutting. The exact outline of this guide-piece can be obtained by placing the thin timber on the table against the fence or wing guide and laying the template on top of it, the finished edge being set against the machine knife. Such a guide ensures that the edges are accurately radial. If only a few segments were required it would be

quite satisfactory to make a pencil mark on the table.

Circular Saws.

For all sorts of straight cuts the circular saw is not indispensable, yet a very valuable tool in the patternshop. A remarkable number of operations can be performed on a circular saw. In shops where there is a band saw it is used for circular work, although it is decidedly wasteful when used for such work. It often takes the place of a planer for scooping out staves for cylinders and columns. It is not very often that a "drunken" saw is used in a patternshop, but there are times when a number of grooves of varying widths are required when a "drunken" saw is an advantage. A "drunken" saw, let it be explained, is a circular saw set on a spindle at other than a right angle, so that when it revolves it does not run in a true path but wobbles sideways. The experienced man has no difficulty in sawing out grooves 1¼ in. wide or 1½ in. wide at one operation. The amount of the "drunkenness" is determined by the method of setting the saw on the spindle. Swivelling pieces are riveted on either side of the saw at its centre, while adjustable collars are locked by means of set-screws to give the necessary degree of saw offset. Owing to the fact that a thick saw cannot readily be set solid, grooving saws are frequently ground thinner at the centre than at the tooth edge.

Applicability of Circular Saws.

The usefulness of a circular saw—and this applies to a hand saw—is in proportion to the condition in which it is kept. One of the first lessons of an apprentice is in sawing timber with a hand saw and he soon learns the necessity for "set." A saw that will cut through one piece of timber easily will choke in another piece of timber. Wet timber requires a saw with more set than dry timber. What actually happens is that the fibre of the wood springs back after the teeth of the saw have cut it. Setting a saw is so bending the alternate teeth to different sides that, as the saw progresses through the timber, the blade behind the teeth has sufficient clearance. This set can be given by means of a punch, but better results are obtained with a tool called a saw-set, which can be adjusted to give any set necessary.

Care of Machine Saws.

A whole treatise could be written on the care of machine saws, but the elementary hints given here will assist the apprentice in understanding why it is necessary to do certain things. When circular or band saws require sharpening it is first necessary to reduce all the teeth to the same length. Were this not done, the strain on the saw would be unequal and some teeth would be doing all the work. It is impossible to obtain a clean cut with a saw that is badly set or sharpened. With regard to sharpening, there is no definite angle for filing the teeth. An experienced man will wedge a circular saw in the saw bench and sharpen it so that all the teeth will be of uniform angle, but, on the other hand, nothing is easier than to get all the teeth at different angles. It is, to a great extent, a matter of experience and care.

When filing rip-saws, the cutting edge should be filed so as to be square across the face of the tooth, while for cross-cut saws, the bevel of the edge should taper to square, about halfway of the length of the tooth. The fillet at the base of the teeth is called the "gullet," and this should always be kept round.

It is impossible to give, in short space, instructions on the truing-up of bandsaw wheels, the correct tension of bandsaws, brazing of saws or packing circular saws. These are all matters which, while they are not usually left to the patternmaker, yet ought to be understood by him. Apprentices should observe closely how such work is done by experienced men. In pattern shops, where the care of the machines is anybody's business, band saws are continually breaking because the bad adjustment of the guides or of too great tension. If circular saws are not properly packed it is impossible to get a good cut, in addition to which the saw will become heated.

Fatigue and Quality of Workmanship.

Cutting large pattern work on a bandsaw is extremely difficult. Generally speaking the largest saws used in a patternshop rarely exceed ¾ in. or ⅞ in., wider saws not being convenient for negotiating curves; these saws are in use for the largest class of work and, as some pattern sections are very difficult to handle, considerable strain is put upon the saw, frequently causing a break. This result occurs at times when a number of men are required to support the piece while being cut. All men do not think alike, and the machine man cannot very well convey his varying desires to each individual assisting in the operation, hence the assistants may actually retard the cutting process. It is preferable, of course, if possible, that the work should be done by one person, without any assistants, as the pressure which is being applied to the saw can then be felt and there is more control in following the cutting line. When much cutting has to be done the men supporting the work get tired, and as the job is not maintained in a horizontal position, it varies above and below the surface of the saw table. This places a great strain on the saw and may result in spoilt work. It is quite a simple matter to have a few roller supports made, such as is shown in Fig. 1. The apprentice may have no power to make these, but it is well that he should understand their great value. Two or three of these supports, having the tops of the rollers level with the surface of the saw table, maintain the horizontal position of the timber to be cut, and the rollers are of great assistance when following a curve.

Another method of supporting large cumbersome pieces, and one which gives greater freedom to the person manipulating the work, is the use of balls set into semi-spherical sockets and set on supports, so that the tops of the balls will be level with the table.

Sand Papering Machines.

The double disc sand papering machine is installed in many patternshops now and supplied with the machine are many useful attachments. In many instances, a handy method can be adopted for sanding circular bodies, and the result though not as good as that obtained with the proper attachment, is fairly satisfactory and certainly better than can be obtained by hand guidance. There are usually a number of holes tapped in one of the tables intended for a pin to supply the fulcrum to a lever in connection with an angle gauge or fence. If a pin is screwed into the most suitable hole for any given work, having a head or collar of say ½ in. dia., and projecting above the table about ¾ in. then, by boring a hole in the centre of the work equal in diameter to that of the pin, the built up job, after being cut near to size on the bandsaw, can be revolved about this pin, the correct diameter being obtained by adjusting the whole table in a horizontal manner. This is usually operated by a hand wheel on the vertical centre of the machine. With the exception of diameters below 6 in., the writers have found this a convenient method when the proper attachment has not been suitable. It is especially applicable for large work, when the table is increased by attaching a drawing board, sufficiently large to provide bearance and centres for setting dowels.

In Fig. 2 are shown a series of diameters which might be worked from the holes in the table, and as adjustments can be made, an almost innumerable number of variations can be obtained between the inside and outside tapped holes. It is essential that these discs should be adequately guarded, but for special work requiring almost the full height of the sander, the guard can be removed to give the worker better facilities for following the line, and as the controlling influence over the work should be in the hands of one person, tallow ought to be applied to the surface of the table when the work is heavy and awkward, in order to reduce friction. Nothing reduces the effectiveness of sanders as much as end grain. Many pattern makers thoughtlessly make use of sand papering machines for the outsides of coreboxes and for squaring large blocks, when a trimming machine would do the work more accurately, and incidentally reduce the depreciation in the value of the sanders.

Notes on Grey Iron for Automotive Castings.*

By H. B. Swan, Detroit, Mich.

Some time ago the writer was requested to prepare something on grey iron mixtures for automotive castings. With this in view, it was suggested that a questionnaire covering the data required be prepared and sent to a representative list of the foundries supplying the automotive industry. About twenty-five foundries comprised the list prepared, and replies were received from sixteen. Many of the latter were incomplete in the answers to questions asked. In regard to the cupola data asked for, it was thought interesting to find out whether the present-day practice approached anything which might be called standard. Furthermore, the writer desired to check some personal observations regarding the total carbon content. The amount and condition of the total carbon is to the writer a point of prime importance for such work as cylinders. Fuel ratio, the percentage of pig-iron, remelt and steel are important both technically and economically. The amount of remelt which can be used without detriment to the casting is a point often discussed. The question of what mixture the foundryman shall use depends on several factors. It may happen that the buyer furnishes certain specifications by which the foundryman must be guided to some extent in compiling his mixture. Special physical tests are not uncommon. In other instances the composition is left entirely to the judgment of the foundryman. Of course, good machining qualities and freedom from the usual foundry defects are understood. As an instance of special requirements, the writer recalls a rather difficult exhaust manifold which the foundry was called upon to make. This casting was polished all over the outside surface previous to a bake enamel. Being a thin-walled casting with some comparatively heavy bosses and flanges, it required considerable experimenting to get the iron which filled all requirements satisfactorily. Another instance is a company which requires that the barrels of the cylinder block shall conform to a Brinell test within certain limits. It often requires the best judgment of several years' experience and some experimental work to meet special specifications for peculiar castings.

Classes of Automotive Castings.

Automotive castings may be conveniently divided into the following classes:—(1) Cylinders, cylinder heads; (2) pistons; (3) crank cases and transmission cases; (4) flywheels and gear blanks; (5) miscellaneous small castings, such as manifolds, pumps, covers, etc.; (6) piston rings.

In making the above divisions, due consideration is made for the shop wherein questions of tonnage, melting capacity, ability to take care of special mixtures from the same cupola, price, etc., are questions of vital importance. On the other hand, a special iron will often cut down losses and be an economy in the end, in addition, perhaps, to meeting the service requirements of the casting most suitably. For instance, for cylinder blocks, which are not cast integral with the upper crank case, it is desirable to have them as hard as the machining will stand. The writer's observation, extending over a period of years, is that hard barrelled cylinder blocks wear best in service. This statement is made on the basis of the number of cylinders returned from service for regrinding from each year's model.

In the writer's experience, cylinders of a proper hardness and composition will run from 30,000 miles to more than 50,000 miles in some cases before needing to be reground. Of course, there are several factors in motor operation which govern the wearing qualities of the barrels, notably, lubrication and the richness of the explosive mixture. Cylinders cast integral with the crank case and crank cases themselves usually require a softer and tougher iron, due to the thin walls and large area to be covered and liability to cracks.

Piston rings are a specialty in themselves, and pistons are better made from special mixtures. Flywheels and gear blanks could well be made in the miscellaneous class, but for the fact that where teeth are cut in them a harder iron wears better. Cylinder iron is usually satisfactory for these castings.

Preparation of Mixtures.

For a detailed method for computing mixtures allowing for losses, the effect of varying the element constituents in grey iron, etc., those unfamiliar with the practice are referred to Dr. Moldenke's "Foundry Practice," and to such articles as Dr. John J. Porter's "Constitution of Cast Iron." Vol. XIX., A.F.A. Transactions. For the foundry making automotive castings, a fair assortment of pig-iron in the yard is quite desirable, if not necessary. This stock may preferably include first a grade of foundry iron best adapted to the general run of work in the shop; secondly, a silvery iron (7 to 10 per cent. silicon); malleable Bessemer; perhaps charcoal* iron for special purposes, and selected scrap and scrap steel.

For such work as cylinders the writer has found that in using scrap steel better results are obtained in the use of steel of fairly good section, such as rails, medium forgings, or heavy boiler-plate clippings. Drop forge flashings are cheaper, but light, and oxidise more readily. Where more than one mixture is used in a shop it is necessary to use care in keeping the remelt separated, if castings of uniform analysis are to be obtained. Under the conditions it is possible easily to vary and control the silicon, manganese, phosphorus and sulphur contents. Silicon is controlled by varying the amount of silvery iron and scrap steel used; manganese, by the use of the ferro-alloy or spiegel; phosphorus, in amount of steel used and perhaps by using some high-phosphorus pig, if it be necessary to raise its percentage; sulphur can to a lesser extent be controlled through the manganese content and by the temperature of melting and slag proportionment.†

Carbon Control.

The carbon content is much more difficult to control, for the iron will take up carbon to the saturation point, depending on the temperature and silicon content; a mixture with a high silicon content that is, 2.75 to 3.00 per cent.—and fairly high sulphur tends to reduce the total carbon. Moreover, melting lower than the correct level above the tuyeres in the cupola has the same tendency. Higher melting has the opposite effect. Then, with a full understanding of the relations of each element and their functions, together with close melting control, it is not difficult to run an iron mixture from day to day with a small variation in composition. Of course, it is understood accurate information is at hand concerning composition of all the raw materials affecting the final product, and frequent analyses, hardness tests, fracture examinations, pouring temperature observations, and sometimes physical tests are necessary adjuncts to close control and getting the most desirable results.

Referring to the tabulated data shown in Table I., it is to be noted that the information shown is representative of the practice of the largest corporation foundries in the United States making castings for cars from among the cheapest makes to the most expensive. Where a range of figures were submitted, the writer has averaged them and used the average figure in the table.

An analysis of the column showing the percentage of pig-iron used in the mixture, a range from 34.3 to 56 per cent. is found, with an average of 44.1 per cent. The experience of the writer has been that it is not desirable to run a mixture with less than 40 per cent. pig-iron for cylinder work. The proportion of steel scrap and remelt to be used depends upon conditions, such as the amount

* A Paper presented to the American Foundrymen's Association Cleveland meeting.

* British equivalent is cold-blast.
† See J. Bolton "Foundry" Sept., 1221.

of remelt available in your own shop and from the rejections from your buyers; also on market conditions. It is easier to buy uniform steel scrap than uniform grey iron scrap.

Carbon.

Again referring to the tabulated data, it is found that the percentage of remelt, scrap, sprues, gates, etc., varies from 25 to 45.7 per cent., with an average of 38.5 per cent., and the scrap-steel content from 10 to 25 per cent., averaging 16.8 per cent. The advantages and disadvantages, if any, in the addition of scrap steel to a mixture have been so widely talked of that it is unnecessary to discuss them here. Steel is a very handy tool for the formulator of the mixtures, as previously pointed out, and in the writer's experience, under proper melting conditions there is little to be said against its use. For this class of work, however, most of the desired results can be obtained with the use of from 15 to 20 per cent.

Considering the use of steel scrap in the cupola from the purely physical benefits to be derived, the prime object in its use is the closing the grain of the iron. In so far that higher percentages reduce the total carbon content of the spout metal, in the opinion of the writer, this is extremely doubtful. Much more control of the total carbon is to be found in varying the silicon content and in the height of the melting zone in the cupola. That height of melting zone in the cupola which gives the hottest iron will also give the highest total carbon for a given mixture, and raising the percentage of steel will reduce the carbon but slightly. Lowering the melting zone will both lower the temperature of the metal and reduce the carbon.

A glance at the columns under total carbon, and under per cent. of steel, shows us that the steel has little influence on the carbon. In No. 1, with 15 per cent. steel, a total carbon content of 3.20 per cent. is found, whereas in No. 2, with 25 per cent. steel, the total carbon content is 0.35 per cent. higher, or 3.55 per cent. No. 11 shows the lowest total carbon, coincident with the highest silicon and sulphur contents, and its steel ratio is lower than No. 2. The following equation, taken from the "Constitution of Grey Iron,"* by J. J. Porter, gives a fair idea of the effect of the other elements on the total carbon:—Per cent. T.C. equals 4.23—0.27 × per cent. Si—0.32 × per cent. P—0.3 × per cent. S plus 0.03 × per cent. Mn.

He further adds that: "The sum of the graphite and combined carbon is dependent upon the conditions of melting in the blast furnace and in the cupola, and upon the percentage of silicon, sulphur and manganese . . . ."

As a matter of comparison, the writer has put in Table I. the specifications of the British Engineering Standards Association for water-cooled aircraft-engine cylinders. To the writer's knowledge, neither the S.A.E. nor the American Society for Testing Materials have any specifications for automotive castings which could be used for comparison. It is to be noted that the graphite is held fairly low in both sets of figures, the silicon is lower, the manganese higher, and the phosphorus much higher, than the average American practice.

Hardness Essential in Bore of Cylinder.

As previously stated, the writer's experience shows that cylinders with hard bores give better wearing service. Hardness is a function of grain size as well as composition, and the grain size is a variable with the rate of cooling. That part of the bore of a cylinder which is surrounded by the water jacket is usually the softest part of the casting, and is softer than a test bar, up to 1-in. section, which is poured from the same ladle, due to the different cooling effects. The barrel of the average automotive cylinder is seldom over ½ in. in thickness as cast. The sand of the water-jacket core and of the heavy barrel core hold the heat so long that an annealing action is obtained in this portion of the barrel. This can be prevented to some degree by the use of hollow steel or iron arbors for the barrel cores covered with only a thin layer, from 3-16 in. to 5-16 in. of sand, and allowing a free circulation of air beneath the bottom board through the arbors and through the cope, if the cylinder is moulded on end. This procedure will raise the hardness of the barrels about 30 to 40 points on the Brinnel scale. Furthermore, low total carbon is desirable. That is, a cylinder from an iron containing 0.50 to 0.60 per cent. combined carbon and about 2.50 to 2.75 per cent. graphite is preferable to one with the same percentage of combined carbon and 3.00 per cent. or over graphite.

Table I.—Cylinders

Number.	Si.	Mn.	P.	S.	C. C.	Gr.C.	T. C.	Per cent Pig iron.	Per cent. remelt.	Per cent Steel.	Fuel ratio.	Tuyere ratio.	Blast Pressure.	Diam. of Cupola inside inches.	Tensile strength tons per sq. in.	Break ½ in. dia. Ar. Bar 12 in.cen.	Deflection in ins.	Brinell hardness.
																Trans.		
1	2.10	0.80	0.20	0.08	0.50	2.70	3.20	40.0	45.0	15.0	1:7.27	1:5.9	12	54	—	—	—	185
2	2.50	0.60	0.55	0.15	0.45	3.10	3.55	35.0	40.0	25.0	1:5	1:5	15	72	17.8	3,100	0.18	185
3	2.25	0.65	0.20	0.10	0.40	3.00	3.40	34.3	45.7	20.0	1:7	1:5	18	78	13.4	3,000	0.15	201
4	2.20	0.65	0.30	0.09	0.20	3.30	3.50	45.0	45.0	10.0	1:8.3	—	11	60	15.1	3,800	0.17	—
5	2.40	0.60	0.22	0.10	0.35	3.00	3.35	43.4	40.6	16.0	1:6.6	1:10.9	13	66	—	3,000	0.14	181
6	2.20	0.65	0.45	0.09	0.50	2.90	3.40	50.0	37.5	12.5	1:6.8	1 :4.7	16	60	14.7	3.300	0.12	217
7	1.75	0.55	0.25	0.08	—	—	—	50.0	30.0	20.0	1:8.3	1: 5.5	13	54	15.0	3,350	0.16	207
8	2.10	0.60	0.22	0.095	0.60	2.80	3.40	55.0	25.0	20.0	1:7.7	1: 2.25	14	60	12.1	3,800	0.135	197
9	2.25	0.60	0.25	0.10	0.45	2.80	3.25	48.9	39.1	12.0	1:8.5	1:8.0	14	54	15.0	3,100	0.14	192
10	2.10	0.60	0.20	0.095	0.60	—	—	56.0	32.0	12.0	1:9.2	—	16	64	—	—	—	100
11	2.85	0.50	0.18	0.15	0.50	2.40	2.90	42.0	40.0	18.0	1:7.4	1: 3.75	11	48	15.0	3,750	0.16	175
12	1.90	0.70	0.18	0.08	0.50	2.90	3.40	38.0	44.0	18.0	1:6.66	1: 5.4	14	54	13.5	4.300	0.13	170
13	2.00	0.65	0.20	0.095	0.50	3.20	3.70	40.0	44.0	16.0	1:8.5	1: 6.1	16	70	—	—	—	175
14	2.50	0.70	0.25	0.90	0.40	—	—	53.5	34.0	12.5	1:7.5	1: 4.1	—	52	—	—	—	—
15	2.70	0.55	0.20	0.10	0.50	2.70	3.20	40.0	37.5	22.5	1:5.9	1: 4.25	11	54	14.5	3,300	0.125	200
16	2.05	0.60	0.15	0.09	0.60	2.80	3.40	43.3	36.6	20.0	1:6.66	1: 4.8	—	72	16.0	4,400	0.25	212
*	1.20	0.80	0.35–	0.12	0.50–	—	2.70–	—	—	—	—	—	—	—	—	—	—	
A	1.80	Max.	0.80	Max.	0.80	—	3.50	—	—	—	—	—	—	—	—	—	—	—
*	1.20	1.10	0.60–	0.12	0.50–	—	2.70–	—	—	—	—	—	—	—	—	—	—	—
B	1.80	Max.	1.20	Max.	0.80	—	3.30	—	—	—	—	—	—	—	—	—	—	—

* The British Engineering Standards Association Specifications for water cooled air craft cylinders.

Silicon.

A further study of the questionnaire shows a silicon range from 1.75 to 2.85 per cent., with the greater number using 2.10 per cent. All points considered, for the average run of cylinder work this is a very satisfactory content to use. Used in conjunction with low phosphorus, it has one disadvantage in that it is provocative of more shrinkage cavities than such a mixture as No. 11. However, if the total carbon is on the low side, the iron sets quickly enough in all sections to overcome this to some extent.

Manganese.

The manganese content, as shown in the table, is remarkably uniform, ranging from 0.50 per cent. to 0.80 per cent. Generally speaking, it would seem a slight excess of manganese over the theoretical amount necessary to take care of any

* A.F.A. Transaction, Vol. XIX.

ill-effects from the sulphur is all that is necessary, although it, perhaps, has some benefits as a deoxidiser.

Phosphorus.

The phosphorus ranges from 0.15 to 0.55 per cent., with the predominating tendency towards the lower end of the range. This practice of using low phosphorus has increased extensively in the last few years, and is due to the fact that the cylinder manufacturer seeks to eliminate the segregation of the fluid phospho-carbides. In doing this, with a low silicon mixture, much of the fluidity of the iron is sacrificed, thereby necessitating hotter melting, which means higher total carbon. The factor of strength does not enter into consideration in this class of work, and the irons with higher phosphorus contents are amply strong; indeed, they will average up well with the lower phosphorus irons.

For obtaining cylinder bores with a high degree of hardness, there is much to be said in favour of the high phosphorus mixtures, such as are typified by the examples shown above of the British Engineering Standards Association, and discussed by Mr. F. J. Cook in his Paper at the last convention of the American Foundrymen's Association. These irons hold their hardness through the cooling range, due probably to the predominating phosphide constituent, and the total carbon content is usually considerably lower than low-phosphorus irons of the same silicon content. Unfortunately, in the experience of the writer, with the pig-irons obtainable in this country, segregation is a frequent and difficult problem to control when such mixtures are used on complicated castings. With castings of simple design and uniform section very good results can be had. But with low-phosphorus irons, the writer's experience has been that the defects due to leaky walls are much reduced.

Sulphur.

The column under sulphur in the data sheet shows a range from 0.08 to 0.15 per cent., with the average about 0.095 per cent. Present-day practice shows an increase in the sulphur content of most grades of castings in this class of work. There are some arguments which can be set forth favourable to a higher allowable sulphur content than was formerly thought possible to use without serious detriment to the casting. Now, for this class of grey iron a predominating pearlite structure is highly desirable. This is entirely in accord with the statement of the writer, made in 1913 (Trans. A.F.A., Vol. XXII.), and also with the results stated by Zimmerschied (Trans. A.F.A., Vol. XXIII.) in his Paper on "Cast Iron with Unusual Structure." A reference to the "Iron Age" issue of December 30, 1915, shows some of the high strength results obtained in Europe in experiments with sulphur in high limits in grey iron. Evidently a sulphur content of 0.15 per cent. is not too high to be detrimental. The writer believes, however, that with the sulphur at such percentage the silicon should be increased somewhat. The writer knows of one cylinder foundry which has been using a mixture wherein the silicon averages about 3 per cent., the sulphur 0.15 per cent., and the phosphorus under 0.20 per cent., for several years with very good results.

Serviceable Mixture.

For a serviceable mixture, all points considered, the writer believes the following mixture very satisfactory to aim at:—Silicon, 1.80 to 2.10 per cent.; manganese, 0.50 to 0.80 per cent.; phosphorus, 0.15 to 0.20 per cent.; sulphur, 0.08 to 0.12 per cent.; combined carbon, 0.50 to 0.60 per cent.; and graphitic carbon, 2.50 to 2.75 per cent. Such a casting should machine satisfactorily, give a good close grain, and wear well in service.

By machining satisfactorily is meant that a cylinder block cast from this mixture can be milled with a cutter speed of from 60 ft. to 80 ft. per min., with a cutting depth of $\frac{1}{8}$ in., and bored with a cutting speed of 45 ft. to 50 ft. per min., with $\frac{1}{4}$-in. cut.

Furthermore, such an iron will have a transverse breaking strength above 3,500 lbs. on the arbitration bar and a tensile strength of over 13.4 tons. These figures are conservative and taken from actual results in the practice of the writer with iron of the above analysis, save that the total carbons were higher (about 3.50 per cent.). The difficulty in obtaining such iron is in getting the total carbon down to the figures indicated.

Fuel Ratio.

Regarding fuel ratio, a variation is found from 1:5 to 1:9.2, with an average of 1:7.33, which is a very good ratio considering the steel ratios, and that this class of work is fairly light, and needs to be melted fairly hot. Coke used on bed is not included in the figures given for ratios.

Under the column on tuyere ratios is found a great divergence in practice with ratios varying from 1:2.25 to 1:10.9. With the exception of Nos. 5 and 10, they are all lower, under 1:6, averaging 1:4.73. Some authorities give 1:7 as the proper proportion, whereas others say about 1:4. Judging from data submitted, there is nothing to be taken as a standard. A comparison of the tuyere ratios to the fuel ratios does not add any

TABLE II.—PISTONS.

Number.	Si.	Mn.	P.	S.	C. C.	Gr. C.	T. C.	Per cent. pig iron.	Per cent. re melt.	Per cent. steel.	Tensile strngth tons per sq. in.	Trans. break 1 ¼ inch dia. Ar. bar. 12in centr.	Deflection in inches.	Brinell hardness.	REMARKS.
1	2.10	0.80	0.20	0.08	0.50	2.70	3.20	40.0	45.0	15.0	—	—	—	—	Same mixture as used for cylinders.
2	2.50	0.60	0.55	0.15	0.45	3.10	3.55	35.0	40.0	25.0	—	—	—	—	Same mixture as used for cylinders.
3	2.40	0.55	0.18	0.10	0.30	3.10	3.40	40.0	44.0	16.0	12.1	2.700	0.16	192	Special mixture for pistons.
4	2.20	0.65	0.30	0.09	0.20	3.30	3.50	45.0	45.0	10.0	—	2.800	—	—	Same mixture for all classes
5	2.50	0.60	0.22	0.10	0.35	3.10	3.45	46.7	41.3	12.0	—	2.800	0.14	174	Special mixture for pistons.
6	2.60	0.65	0.50	0.06	0.25	3.25	3.50	50.0	45.0	5.0	13.4	3.000	0.12	192	Mixture used for all small work.
7	1.75	0.55	0.25	0.08	—	—	—	50.0	30.0	20.0	15.0	3,350	0.16	207	Same mixture as used for cylinders and crankcases.
8	2.10	0.60	0.22	0.95	0.60	2.80	3.40	55.0	25.0	20.0	12.2	3,800	0.135	197	Same mixture as used for cylinders.
9	2.50	0.60	0.30	0.09	0.29	3.55	3.40	56.5	41.3	2.2	12.2	2,450	0.16	—	Miscellaneous small castings.
10	2.10	0.60	0.20	0.95	0.60	—	—	56.0	32.0	12.0	—	—	—	190	Same mixture used for all classes of work.
11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given.
12	2.50	0.70	0.15	0.07	0.45	3.00	3.45	45.0	40.0	15.0	10.7	3,400	0.12	160	Special mixture for pistons.
13	2.40	0.65	0.30	0.95	0.35	2.95	3.30	40.0	44.0	16.0	—	—	—	165	This mixture used on all classses except cylinders.
14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given.
15	2.75	0.55	0.20	0.10	0.40	2.95	3.35	40.0	50.0	10.0	13.6	3,100	0.125	180	This mixture also used for flywheels.
16	2.35	0.60	0.18	0.09	0.55	2.95	3.50	43.3	46.7	10.0	12.5	3,400	0.187	196	This mixture also used for crankcases.

light on the subject, for No. 8, with a tuyere ratio of 1:2.25 and a fuel ratio of 1:7.7, is little different in fuel consumption than No. 9, with a tuyere ratio of 1:8. It hardly seems possible that there should not be a ratio between the area of the tuyeres and the area of the cupola which gives the best melting conditions. There is a need still for data on cupola design.

Pistons.

Table II. on pistons shows the data arranged under the same numbers as in Table I. Some replies gave no data on pistons, so that there the spaces opposite those numbers are vacant. It is to be noted that *among those using a special iron* for pistons that the silicon content is higher, running from 2.35 per cent. to 2.75 per cent., the manganese content about the same as for cylinders, likewise the phosphorus and sulphur; the combined carbon lower, averaging about 0.35 per cent., as against 0.47 per cent. for cylinders. The total carbons are about the same as for cylinders. The per cent. of pig-iron used is a little higher, averaging a little more than 45 per cent., but the percentage of steel is lower, averaging about 11 per cent. only. The average percentage of remelt is thereby raised a little, averaging about 44 per cent. These figures would be changed but little, even if the mixtures as indicated for cylinders were included. The drop in strength is quite noticeable, which is to be expected from the difference in analysis.

Present-day practice is to make pistons as light as possible, and extensively with green-sand cores. They can be cast with wall thickness as low as 3-32 in. With such light sections, however, there is a severe tendency to get chilled spots when using mixtures with low phosphorus. The wrist-pin bosses are heavy, and there is usually trouble in preventing shrinkage cavities between these bosses and the wall of the piston. A higher silicon content, say, from 2.50 to 2.75 per cent., is desirable, for it serves several purposes, counteracting the shrinkage above mentioned, minimises the blows, and counteracts the chilling tendency of the quick-setting iron. Hot melting is essential, for the metal should come from the spout higher than 1,425 deg. C. Another trouble of considerable importance with such light castings is the loss due to cracks. Many machine shops use air expanding chucks, holding the piston from the inside and causing considerable strain on the casting. It is well to toughen the iron by the use of a fair percentage of charcoal iron in the mixture, say about 20 per cent. For this purpose the writer has used the Lake Superior charcoal brands to good advantage. For especially high-grade pistons, where expense is not of prime importance, from 4 to 5 per cent. nickel may be used to advantage, giving a product when machined of beautiful finish, extremely fine grain, and high strength, about 16 to 17 tons tensile strength, and uniform hardness.

On pistons, it is good practice after the rough cut in the machine shop to anneal sufficiently to remove casting strains. This to a large extent prevents the casting from going out of round on the final operations.

An analysis of the data on small castings given in Table III. reveals a range from a low silicon, hard iron in No. 3, to soft, rather high silicon irons such as Nos. 12 or 15, with the latter in a predominating majority. No. 3 stands out really as an exception to the usual run of irons for this class of work. It is interesting to note here, as a further instance of the effect of steel on the total carbon, a comparison with No. 8. Both contain approximately the same amount of steel in the formula, but a noticeable difference in the carbon percentages. No. 3 is melted in a 36-in. cupola with 2,200 lbs. of coke on the bed. The fuel ratios are not very different, No. 3 being 1 to 6.6 and No. 8 being 1 to 7.6. It would seem that No. 3 is melted lower than No. 8, which accounts to some extent for the difference in the carbon. As a rule, castings in this class are not as complicated and variable in section as are cylinders and crank cases, and strength is not of primary importance. They can therefore stand being made softer and from a more fluid iron, with machining qualities given much more consideration. As said before, where possible, it is well to use the iron that gives the best results to the work at hand, and the composition and proportionment of the pig-iron, remelt and steel is largely a matter of experience and judgment.

It is of interest to note that in No. 3 only 25 per cent. of pig-iron is used, which is the minimum in all the mixtures submitted. Oftentimes the ailments of defective castings are attributed to lack of sufficient pig-iron in the mixture, but the writer is familiar with the foundry using this mixture, and the class of work turned out, and believes if it were not of proved value it would not be submitted in the questionnaire. The experience of the writer has been that defects such as shrinks and draws have often been remedied by raising the percentage of pig-iron when using less than 40 per cent. pig-iron, even though the analyses may be nearly identical in the two instances. For this class of work the writer has

Table III.—Miscellaneous Small Castings.

Number.	Si	Mn.	P.	S	C. C.	Gr. C.	T. C.	Per cent. pig iron.	Per cent. remelt.	Per cent. steel.	Tensile strength tons per sq. in.	Trans. break 1 inch dia. Ar. bar. 12in. centr.	Deflection in inches.	Brinell hardness.	REMARKS.
1	2.30	0.60	0.40	0.80	0.40	2.80	3.20	40.0	60.0	—	—	—	—	—	Same mixture as used for crankcases.
2	2.50	0.60	0.55	0.15	0.45	3.10	3.55	35.0	40.0	25.0	17.8	3,100	0.18	185	Same mixture used for all classes of castings.
3	1.00	0.50	0.25	0.11	0.70	2.45	3.15	25.0	40.0	35.0	14.2*	3,200*	0.14	229	*1 in. x 1 in. x 15 in. used. This mixture used only for small castings.
4	2.20	0.65	0.30	0.09	0.20	3.30	3.50	45.0	45.0	10.0	15.1	3,800	0.17	—	Same mixture used for all classes of castings.
5	2.65	0.60	0.22	0.075	0.25	3.30	3.55	61.6	33.4	5.0	—	2,220	0.16	153	Same mixture as used for crankcases.
6	2.60	0.65	0.50	0.09	0.25	3.25	3.50	50.0	45.0	5.0	13.4	3,060	0.12	192	
7	2.10	0.60	0.34	0.08	—	—	—	50.0	30.0	20.0	12.5	2,800	—	170	
8	2.40	0.60	0.50	0.09	0.35	3.10	3.45	56.25	6.25	37.50	9.5	2,800	0.12	170	Same mixture as used for crankcases and flywheels.
9	2.50	0.60	0.30	0.09	0.25	3.15	3.40	56.5	41.3	2.2	10.7	2,450	0.16	—	
10	2.10	0.60	0.20	0.095	0.60	—	—	56.0	32.0	12.0	—	—	—	190	Same mixture used for all classes of castings.
11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given on any class except cylinders.
12	2.50	0.60	0.25	0.06	50.40	3.20	3.60	38.0	53.0	8.0	—	—	—	145	
13	2.40	0.65	0.30	0.095	0.35	2.95	3.30	40.0	44.0	16.0	—	—	—	165	Same mixture used for all classes of work except cylinders.
14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given on any class except cylinders.
15	2.60	0.55	0.37	0.10	0.30	3.05	3.35	40.0	50.0	10.0	11.3	2,600	0.15	170	
16	2.65	0.60	0.22	0.09	0.45	3.15	3.60	43.3	51.7	5.0	9.8	2,400	0.125	174	

used for a number of years a mixture of about the following composition:—

	Per cent.
Si.	2.40-2.60
Mn.	.50- .70
P.	.25- .35
S.	.06- .08
C. C.	.30- .40
Gr. C.	3.10-3.30
Pig Iron about	40
Remelt ,,	50-52
Steel ,,	8-10

There is little to comment on in the data on crank cases in Table IV. Most of the foundries use either the cylinder iron or the softer iron used for small castings. None use special iron for flywheels, but in most cases use cylinder mixtures, especially where teeth are cut in the rim of the flywheels. The cupola practice is practically in every case a facsimile of that shown with the cylinder data.

To show the interest which some of the foundries manifested in data requested on the questionnaire, one large automobile corporation foundry submitted the ideal mixtures as viewed by their metallurgist, foundry superintendent, and assistant foundry superintendent.

The Secretary thought that the item of £140 17s., outstanding subscriptions, might be regarded as a good asset.

Mr. F. J. Cook (Birmingham) was elected president, Professor Turner observing that he was an eminent foundry expert, both in this country and abroad. Mr. T. E. Lester said that Mr. Cook had not only a general iron and steel reputation but what might be called a cast-iron reputation, which was a matter of great importance at present.

Mr. H. B. Jacks was elected vice-president, in succession to Mr. Cook. Mr. Jacks, it was mentioned, had already been appointed to the presidency of the Birmingham Metallurgical Society for next session. Mr. Piper, who has been connected with the institute for more than 30 years was re-elected.

Mr. Chas. Pugh, who was heartily thanked for his past services, retired from the position of Secretary, and Mr. C. H. Plant was elected in his place. The annual excursion has been fixed for June 30, when a visit is to be made to the works of the Stanton Iron Company, Nottingham. The firm have expressed the hope that the members will arrive early enough to inspect their centrifugal pipe-casting process.

TABLE IV.—CRANKCASES.

Number.	Si.	Mn.	P.	S.	C. C.	Gr. C.	T. C.	Per cent. pig iron.	Per cent. remelt.	Per cent. steel.	Tensile strength tons per sq. in.	Trans. break 1 inch dia. Ar. bar. 12in. centr.	Deflection in inches.	Brinell hardness.	REMARKS.
1	2.30	0.60	0.40	0.80	0.40	2.80	3.20	0.40	60.0	—	—	—	—	—	Same mixture as used for crankcases.
2	2.50	0.60	0.55	0.15	0.45	3.10	3.55	35.0	40.0	25.0	17.8	3,100	0.18	185	Same mixture used for all classes.
3	2.25	0.65	0.20	0.10	0.40	3.00	3.400	34.3	45.7	20.0	13.4	3,000	0.15	01	Same mixture used for cylinders and flywheels.
4	2.20	0.65	0.30	0.09	0.20	3. 0	3.50	45.0	45.0	10.0	15.1	3.800	0.17	—	Same mixture used for all classes.
5	2.65	0.60	0.22	0.075	0.25	3,30	3.55	61.6	33.4	5.0	—	2,200	0.14	174	Same mixture as used for miscellaneous class.
6	2.20	0.65	0.45	0.09	0.50	2.00	3.40	50.0	37.5	12.5	14.2	3,300	0.12	217	Same as for cylinders.
7	1.75	0.55	0.25	0.08	—	—	—	50.0	30.0	20.0	14.9	3,350	0.16	207	Same as for cylinders.
8	2.40	0.60	0.60	0.09	0.35	3.10	3.45	56.25	6.25	37.5	9.5	2,800	0.12	170	Same mixture used on flywheels and miscellaneous class.
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given.
10	2.10	0.60	0.20	0.095	0.60	—	—	56.0	32.0	—	—	—	—	190	Same mixture used for all classes.
11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given
12	2.50	0.65	0.40	0.08	0.35	3.00	3.35	50.0	50.0	—	12.0	2,720	0.10	180	Same as used for miscellaneous class.
13	2.40	0.65	0.30	0.095	0.35	2.95	3.20	40.0	44 0	16.0	—	—	—	165	Same as used for pistons and miscellaneous class.
14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given.
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No data given.
16	2.35	0.60	0.18	0.09	0.55	2.95	3.50	43.3	46.7	10.0	12.5	3,400	0.187	196	Same mixture as used for pistons and miscellaneous class.

South Staffordshire Iron and Steel Institute.

At the annual meeting of the Staffordshire Iron and Steel Institute, held at Dudley, the President, Mr. Joseph Payton, occupied the chair. The report of the Council expressed regret at the recent death of Mr. C. E. Roberts, and two old life members, Mr. John Paterson and Mr. W. J. Hudson. The balance sheet showed that £223 6s. 9d. had been carried forward, as against £208 15s. 6d. the previous year, showing a gain of £14 11s. 4d. The total amount of arrears owing at December was £186 9s., and of this amount £45 12s. had been written off, leaving a balance of £140 17s., brought forward, the whole amount of which was considered good.

Professor Turner (Birmingham) referred to the slight falling off in membership, and added that they might anticipate a little deficiency next year. That seemed to be inevitable if they had the same expenses with a reduced membership. Mr. Piper thought that the increased subscription would give them sufficient to counteract the falling off in membership.

Personal.

MR. R. ANGUS, chairman of William Baird & Company, Limited, died recently, aged 87.

MR. A. W. KENT, who, until his resignation at the end of last year, was for over 40 years a director and secretary of Harrison & Company (Lincoln), Limited, malleable ironfounders, died recently, aged sixty.

COLONEL J. L. MARR, managing director of the Sunderland Forge & Engineering Company, Limited, has been elected as a life honorary member of the Newcastle and District Association of Foremen Engineers and Draughtsmen.

SIR HUGH BELL, chairman and managing director of Bell Bros., Limited, of Middlesbrough, has left for a tour in the Near East.

MR. CHAS. WIGGINS, a director of Hanson, Brown & Company, Limited, Middlesbrough, has joined W. Fletcher & Son, Limited, iron and metal merchants, 2, Park Row, Leeds.

MR. W H. PARKER, formerly of Robt. Sorby & Sons, Limited, tool makers, Sheffield, has been elected a director of F. G. Pearson & Company, Limited, edge tool makers, of Hope Works, Furnace Hill, Sheffield.

MR. C. VYLE, managing director of W. & T. Avery, Limited, has been elected president, and Mr. J. Belliss, a director of Belliss & Morcom, Limited, vice-president, of the Birmingham Chamber of Commerce.

Institution of British Foundrymen.

LANCASHIRE BRANCH.

The annual meeting of the Lancashire Branch was held on May 5 at the Municipal College of Technology, Manchester, Mr. J. Haigh presiding.

A resolution of sympathy with the family of Mr. R. Harling, who recently passed away, was carried by the members rising in their places.

The minutes of the last annual meeting were read and approved.

The Secretary (Mr. Mackemson) read the annual report and balance-sheet, in which he said the Branch had made progress, numerically and also in interest and usefulness. It was an added satisfaction that this had been done, despite adverse conditions due to trade depression. The membership (including the Burnley section) consisted of 85 members, 167 associate members, 3 associates and 7 subscribing firms, a total of 262, which was 13 more than last year's total. Twelve Council meetings and several sub-committee meetings had been held. The balance-sheet showed an income of £82 1s. 8d. and the expenditure £63 5s. 8d., leaving a balance in hand at the end of the year of £18 16s., against £6 8s. 2d. last year. The amount received in subscriptions and remitted to the general office was £323, and the Council were entitled to claim one-third, viz., £107 13s. 6d., but the amount actually claimed and received was £75. The syllabus had been of a very varied character, and covered many aspects of modern foundry practice. Three visits had been paid to works. The Burnley section had met regularly, and was very active and enterprising. Its membership now comprised 21 members and 24 associates.

On the motion of Mr. S. G. Smith, seconded by Mr. Horrocks, a vote of thanks to those who had held office during the year was passed unanimously.

Election of Officers.

The Chairman observed that he considered the Branch had had a very good year, and they had reason to congratulate themselves on having a very good secretary.

Mr. R. A. Miles was elected President, and presided over the subsequent proceedings. The other officers elected were:—Senior Vice-President, Mr J. Masters; Junior Vice-President, Mr. S. G. Smith. Messrs. Nicholls, Jowett and Stead were elected to serve on the committee for two years, and two vacancies created by the resignations of Mr. W. H. Cook and Mr. Jolley were filled by Mr. Layfield and Mr. Grimwood. The delegates chosen for the General Council were Messrs. Hogg, Smith, W. H. Sherburn, Senr., Key and Grimwood.

LANCASHIRE BRANCH.

Burnley Section.

The annual meeting of the Burnley Section of the Lancashire Branch was held on Tuesday, May 1, at the Municipal College, Burnley, Mr. J. Hogg presiding.

The chairman said during his term of office, which was now coming to an end, he had found his work as president comparatively easy. He attributed that to the efficient manner in which the secretary and the members of the Council had discharged their duties, and he moved a vote of thanks to them.

The motion was seconded by Mr. Vernon, and passed unanimously.

The secretary (Mr. J. Pell) read the annual report, in which he stated that the members could congratulate themselves on the state of the Branch at the close of its second session. Active interest was taken in it, and a varied programme of lectures and discussions had been carried through. Eleven Council meetings had been held, and also eight branch meetings, and the attendance had been good.

The chairman said Mr. R. H. Place, the senior vice-president, desired to be excused from not undertaking the duties of president on account of advancing years. Under those circumstances he moved the election as president of Mr. A. Hartley.

Mr. Hartley presided over the subsequent proceedings.

Other officers were elected as follows:—Senior vice-president, Mr. G. Barnes; junior vice-president, Mr. Beecroft. Council: Messrs. Jackson, Castree, and Christie, with Mr. Taylor to act for one year only. Delegate to General Council: Mr. Beecroft. Honorary Secretary: Mr. J. Pell.

LONDON BRANCH.

Annual General Meeting.

The annual general meeting was held at the Institute of Marine Engineers, on May 5, the Branch-President, Mr. Wesley Lambert, in the chair. The minutes of the previous annual general meeting were read, confirmed and signed.

Election of Officers.

The Branch-President, in opening the proceedings, said that at the last Council meeting of the Branch it had been thought well, in order to expedite the business of the annual general meeting, to depart from the usual procedure, and for the Council to nominate officers and members of Council, always with the reservation, of course, that any member present could also put forward a nomination. Colonel W. F. Cheesewright, the senior vice-president, should, of course, pass into the chair, but he regretted that, owing to the state of his health, he felt that it was impossible for him to take office. He (the President) felt sure that the members sympathised very much with Colonel Cheesewright in his indisposition, and he was confident that, notwithstanding the fact that Colonel Cheesewright was not passing into the Presidential chair, the Branch would have a great friend in Colonel Cheesewright, and that he would continue, all being well, to be a member of Council. Mr. G. C. Pierce, the junior vice-president, preferred to take the position of Senior Vice-President, and not to take the Presidential chair until a later period. Under those circumstances, therefore, the Council had recommended Mr. V. C. Faulkner (hon. secretary) as President of the Branch for the forthcoming session. The following officers were then elected:—President, Mr. V. C. Faulkner; vice-president, Mr. G. C. Pierce; junior vice-president, Mr. R. J. Shaw; hon. treasurer, Mr. R. J. Shaw; hon. secretary, Mr. H. O. Slater; members of Council, Colonel W. F. Cheesewright, Messrs. G. Hall, H. S. Clark and H. Shillto; auditors, Messrs. H. Cole Estep and A. R. Bartlett; delegates to General Council, Colonel Cheesewright and Mr. W. Lambert.

Continuing, the Branch-President said that Mr. Shaw had been acting as treasurer of the Branch, and the Council were very pleased that Mr. Shaw had been willing to accept the office of junior vice-president. He would, however, continue to act as hon. treasurer. Mr. Slater, an immediate past-president of the Branch, had kindly consented to accept the office of hon. secretary.

The Branch-President said he would like an opportunity of thanking all his officers and the Council of the Branch for their good services during the past session, and also of thanking the members as a whole for the help, assistance and encouragement they had given him during his year of office as Branch-President. He felt very much indebted to the officers of the Council, and particularly to Colonel Cheesewright, who had placed a room in his offices at the disposal of the Council for the holding of all their meetings, and other hospitality. He would like to express the thanks of the meeting to Colonel Cheesewright.

Mr. Bartlett said he supposed it was understood that the new officers and members of Council did not act until October next, which was the beginning of the next session.

The Branch-President replied that that was the usual practice.

This concluded the business of the meeting.

The partnership heretofore subsisting between Messrs. T. A. E. Fletcher and G. C. Robinson, lock manufacturers, metal workers, etc., Combination Works, Willenhall, under the style of Lowe & Fletcher, has been dissolved. Messrs. Robinson and Jones will continue the business.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

What is that Man Doing?

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Some time ago you published a rather miserable letter from a moulder, who felt he was up against a brick wall and could not get a foreman's job. An aspect of this problem is, we hope, crystallised in the following remarks:—

The junior factory official should be ambitious, and with a view to furthering his own interests he naturally takes advantage of any circumstance which, in his opinion, can be utilised in his favour. He is determined to "get on," and having become more or less proficient in the discharge of the duties assigned to him, he is not disposed to "hide his light under a bushel," but instead allows its brightness to radiate from his person, for the purpose of attracting the attention of the higher officials.

With a sublime belief in his own ability (which may or may not be justified) he is not afraid to court the notice of the management. His position may be of small account, but such as it is, he believes he is master of it. His immedate superior accepts his services as a matter of course—he is a useful man, and he is convinced that he has only to be noticed by the manager for the latter to seek out the head of the department and remark, "That is a promising young fellow you have there: we must promote him."

So he sets out to attract attention, but the result is not always in accord with the expectation. Works managers are apt to view matters from a very different standpoint, and instead of being impressed they are irritated. The wisest thing that the ambitious young man can do is to go "all out" to please the head of his department, and to avoid the eye of the manager. The chief appreciates proficiency and brilliance because, being directly interested, he understands; but the manager, perceiving only a discordant element in an otherwise tranquil atmosphere, is goaded to say, "What *is* that man doing?"

One young man was appointed to assist the foreman of a department in an administrative capacity, and so proficient was he that his active duties left time for observation, and maybe contemplation. His was a noticeable figure as he stood in a prominent position, and he might well be taken for the department head by anyone entering the factory. With his hands loosely clasped behind his back he seemed to be directing operations with an entire absence of hustle; and, the manager's office overlooking the spot upon which he was wont to stand, he was bound to attract attention.

The manager looks and then frowns! He is personally acquainted with the heads of the various departments, but this fellow he cannot place. Who is he? His secretary cannot supply the information, and for the moment the matter drops. But to-morrow he is there again, and the next day, and the next, till at length the manager becomes genuinely annoyed. Sending for the foreman he abruptly asks who the fellow is, and upon being told, suggests that perhaps he can be given duties which will remove his presence from that one spot.

Let us give another illustration. The man in this instance was a progress chaser, and he held a sort of roving commission throughout the factory. He was smart enough at his job, though his appearance was by no means distinguished, and were it not for the fact that he was for ever encountering the manager, he would have remained unnoticed amidst his surroundings.

The regularity of the encounter occasioned the manager first surprise, then annoyance, and finally exasperation. "What the deuce is *he* doing?" was the question provoked, and although there was no doubt that the man was following his legitimate pursuits, the constant meetings had an unfortunate effect upon the temper of the manager.

The prospects of these men were affected by the endeavour to attract attention; but not in the manner anticipated, for one cannot exasperate a works manager with impunity. The manager has manifold worries and troubles to contend with, and some of these must of necessity be passed on. The difficulty, in many instances, is to find a suitable victim, and when an opportunity offers for the outpouring of his wrath, it is too much to expect that it will be ignored. The unsuspecting victim, in his desire to please, has imperilled his own prospects, for hereafter every petty delinquency is magnified a thousandfold. He has succeeded in attracting attention, but he has also succeeded in conveying a wrong impression, and for this he is bound to suffer.

There is a moral to this, which is: "Don't court the limelight." It may be that one's efforts are not appreciated as one would wish, and that promotion is tardy; but better let progress be slow yet sure, rather than risk all upon one throw which, if it fails, may mean the ruin of one's prospects owing to the misinterpretation of the motive which prompted it. Let such aspirants study psychology in their spare time.—Yours, etc.,

W. H.

Vanadium in the Steel Foundry.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I regret that through enforced absence I have not been able previously to answer the editorial comments and questions appended to my article on "Vanadium in the Steel Foundry," published in your issue of April 12.

My insistence on the use of ferro-vanadium "technically free from carbon"—to the technologist the description embraces only those alloys and metallic products which have been reduced by means other than carbon—in the steel bath, in order to get the best results from the addition, is due to my observation of the evils arising from "non-dissociation." It is, I think, an easily attainable ideal that molten steel at the time of teeming consist of an elementary solution of various components in molten iron, as free as possible from all inclusions. The binary or more complex compounds with which we are all familiar in solid steel are formed at or about solidification.

An alloy reduced by carbon may contain its carbon in various associations. If one of these associations be not destroyed at the temperature of the bath we do not have our ideal condition, and the correct complex compounds are not formed after casting. In addition, the undissociated carbides give arise to actual mechanical trouble; on the top of all this they have prejudiced solution of the alloy. Thus we have "Pelion piled upon Ossa" in the way of bad results.

Carbonless alloys *cannot* contain this trouble-maker; carburetted alloys *may*. If the chemist can assure us that a batch of carburetted alloy does not contain it, by all means use the alloy if arithmetical conditions of composition allow. But as no laboratory can give us such a pronouncement, on the simple principle of insurance we must use an alloy "technically free from carbon."

Ferro-vanadium is by no means the only alloy which in my experience can give trouble from this cause; molybdenum, titanium and chromium ferro-alloys are all venial.

The hard spots in the titanised cast iron are, in my opinion, very likely to arise from such cause.

It is a point of great argument as to whether oxygen can exist in cast iron in any combination with the iron itself; in considering it we must also consider the questions of chemical equilibrium and of mass, as further affected by temperature.

But I do not attribute any of the good results which arise from the addition of vanadium or titanium to *good* cast iron to the fact that they are—almost, unfortunately in this case—deoxidisers. They do de-nitrogenise, and the deleterious effect of nitrogen content in iron and steel forms a subject which is worthy of much more attention than it receives.

And the addition of vanadium at least to cast iron produces many other beneficial effects.

Yours, etc.,

J. KENT SMITH.

1, Staniforth Road, Attercliffe,
Sheffield.
May 10, 1923.

Trade Talk.

Lawson, Walton & Company, Limited, St. Nicholas Buildings, Newcastle-on-Tyne, are now acting as the Northern representatives of E. Roper & Company, foundry engineers, Keighley.

The shareholders of Dorman, Long & Company, Limited, have approved the resolution submitted by the directorate increasing the capital from £7,500,000 to £8,050,000 by the creation of additional 550,000 shares of £1 each.

Mr. T. Thomas, formerly a partner in Elliott & Sykes, Albert Road, Middlesbrough, has established himself in business as an iron and steel merchant at Commercial Chambers, Middlesbrough, under the style of Thos. Thomas & Company.

The Joseph Dixon Crucible Company announce price reductions on all their graphite specialities (with the exception of paint). This is the third reduction since 1920, and now brings the company's specialities down practically to pre-war prices.

Mr. R. H. Cheyne, a director of Hanson, Brown & Company, Limited, has established himself in business at Queen Square, Middlesbrough, as Robert Cheyne & Company. He will take over the metal branch of the business of Hanson, Brown & Company, Limited, and will shortly remove to Manton Street, Middlesbrough.

The profits of Vickers, Limited, for 1922 were £683,205 (as compared with £708,103 in 1921), while £872,993 was brought forward. After allowing for the preference dividends for the year, it is proposed to pay a dividend of 5 per cent., less tax, on the ordinary shares for the year, leaving £703,907 to be carried forward.

An advance of 10¾ per cent. has accrued to Cumberland and North Lancashire blastfurnacemen as the result of the April ascertainment, which shows that the average selling price of West Coast Bessemer mixed numbers was £5 5s. 8d. per ton, against £4 15s. 8d. at the previous ascertainment. The wages are now 44½ per cent. above the standard.

Licences under the Non-Ferrous Metal Industry Act, 1918, have been granted to Alexander & Company, Limited, London; Lempriere, O. T., trading as O. T. Lempriere & Company, London; and Stewart & Sons, R.F., Newcastle-on-Tyne; Brindley, L. K., 25, King William Street, London, E.C.4; Coulls, A. J., 8, Union Court, Old Broad Street, London, E.C.2; Mountain, H., 82, Farringdon Street, London, E.C.4.

Mr. E. Seymour Wood, late of the South Hetton Coal Company, Limited, has concluded arrangements to represent the Harland Engineering Company, Limited, and the British Electric Plant Company, Limited, on the East Coast, with headquarters at Newcastle. Mr. Wood is well known on the North-East Coast, and has been for 12 years on the council of the Institution of Mining Electrical Engineers and the North of England Institution of Mining and Mechanical Engineers.

The British Section of the Canadian National Exhibition will include exhibits from Cleeves Western Valleys Anthracite Collieries, Limited, Ackroyd & Best, Limited, Brown Bayley's Steel Works, Limited, John Davis & Son (Derby), Limited, Allen Everitt & Sons, Limited, J. & W. Marshall & Company, Mellowes & Company, Monk Bridge Iron & Steel Company, Limited, North-Eastern Marine Engineering Company, Limited, Perry Bevan & Company, Limited, Vickers, Limited, and Henry Foster & Company, Limited.

Parkinson's (Australia), Limited, have laid out a works at Sydney to duplicate the manufacture of the products of the parent company, F. & A. Parkinson, Limited, Guiseley, Leeds, who advised materially in regard to the lay-out of the Australian works. The works have been designed to provide for the construction of electric motors on a large mass production basis, and are situated in the centre of a residential suburb about 4½ miles out of Sydney city, which enables the company to secure a good class of workmen. The factory site covers about 6 acres, and ample room has been left for extension.

Mr. Henry Wilkes, Eyre Street, Birmingham; John Slater, Limited, 134, Palmerston House, Bishopsgate, London, E.C.2; Allen West & Company, Limited, Lewes Road, Brighton; Latch & Batchelor, Limited, Hay Mills, Birmingham; John Nicholson & Sons, Limited, Hunslet, Leeds; British Tar Products Limited, 11 and 12, Pall Mall, London, S.W.1; the Yorkshire Coking & Chemical Company, Limited, 11 and 12, Pall Mall, London, S.W.1; the Midland Electric Manufacturing Company, Limited, Stafford Works, Barford Street, Birmingham; Casebourne & Company, Limited, Haverton Hill-on-Tees; and T. Rowbotham & Company, Limited, Victoria Engineering Works, Portwood, Stockport, have joined the F.B.I.

Company News.

Siemens Brothers & Company, Limited.—Profit, £14,041; no dividend on ordinary or preference shares.

A. J. Bennett & Weaver, Limited, 28, Broadway, Bexley Heath.—Capital £10,000 in £1 shares. Engineers.

Holden Suspension Company, Limited, 30, Wood Street, Manchester.—Capital £10,000 in £1 shares. Engineers.

Croft Engineering, Limited, Albion Works, Central Street, Bolton.—Capital £3,000. Directors: J. A. Holt and J. W. Cryer.

Bussanei Engineers, Limited, 2, Northport Street, London, N.1.—Capital £1,000. Life directors: T. H. Buss and G. Ellston.

Higginson & Company (Engineers), Limited.—Capital £10,000. Solicitors: Simpson, North, Harley & Company, 1, Water Street, Liverpool.

Rotherham Scrap Iron Company, Limited, Imperial Buildings, Rotherham.—Capital £5,000. Provisional directors: J. Campbell and W. W. Hepworth.

Roberts & Company (Hull), Limited.—Capital £1,000. Ironfounders and engineers, etc. Directors: H. Roberts, Mrs. A. Roberts, and A. Leatham.

Dorman, Long & Company, Limited.—Dividend on preferred ordinary, 8 per cent. per annum, less tax, for half-year; no interim distribution on ordinary.

Construction & Contracts, Limited, 110, Victoria Street, London, S.W.—Capital £2,000. Engineers, etc. Provisional directors: J. A. G. Leask and S. Bennells.

A.E.G. Machinery & Apparatus Company, Limited, 76, Victoria Street, Westminster, London, S.W. – Capital £10,000. Directors: R. T. Durran and J. E. Percival.

Creese & Company, Limited, 7, Lancaster Place, London, W.C.—Capital £6,000 in 5,500 8 per cent. non-cumulative preference shares of £1 and 10,000 ordinary shares of 1s. Engineers.

G. Robertson, Limited, 28, Back Rothbury Terrace, Heaton, Newcastle-on-Tyne.—Capital £1,000 in £1 shares. Pattern makers, etc. Directors: G. Robertson (chairman) and G. E. Robertson.

Brimscombe Foundry and Engineering Company, Limited, Lower Mills Foundry, Brimscombe, Glos.—Capital £2,000 in 20,000 preference shares of 1s. and 1,000 ordinary shares of £1. Directors: W. J. Bloodworth, J. Cousins and J. J. Shipway.

Obituary.

Mr. W. Slater, of White House, Husthwaite, near Easingwold, Yorks, a partner in the firm of John Slater & Sons, agricultural engineers, died recently in his 69th year.

Sir Henry Hollingdrake, a director of Francis Shaw & Company, Limited, and principal of the Hollingdrake Automobile Company, died at Buxton last week, aged 51.

Mr. H. L. Davies, a director of Cochran & Company (Annan), Limited, died suddenly at Birling Gap, near Eastbourne, recently. The deceased was born at Markham Clinton, Notts, in 1866.

Mr. G. A. Boeddicker, well-known in Birmingham business circles, died at Harborne recently. He was managing director of Henry Wiggin & Company, Limited, one of the principal metal rolling firms in the city, and was one of the founders of the Institute of Metals.

Mr. George Rae Anderson, who commenced business in his own name as an iron and steel merchant in Liverpool in 1874, died on April 28 last, at Hoylake, in his 75th year. The deceased gentleman was also the proprietor of the coal, coke and cannel shipping firm of W. B. Ihne & Company, of 13, Rumford Street, Liverpool.

Open Contracts.

Dublin, May 21.—Stores, for the Midland Great Western Railway of Ireland Company. The Storekeeper, General Stores Department, Broadstone Station, Dublin. (Fee, 6d.)

London, S.W., May 22.—Galvanised ironware, for the Commissioners of His Majesty's Works, etc. The Controller of Supplies, H.M. Office of Works, etc., King Charles Street, Westminster, London, S.W.1.

Professor C. H. Desch, F.R.S., of Sheffield University, has been appointed a member of a special committee of the Building Research Board set up under the Department of Scientific and Industrial Research Board to report on the best methods by which decay in building stones, especially in ancient structures, may be prevented or arrested.

The . . .

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Sulphate of Iron,
Red Oxide of Iron,
Bleaching Powder,
Caustic Soda,
Accumulator Acid,
Creosote Oil,
Green Oil, Pitch,
Sulphate of Ammonia,
Muriate of Ammonia,
B.O.V. & R.O.V.
Oleum (all strengths),
Pure Sulphuric Acid,
Nitric Acid,
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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Business in the Cleveland iron market must again be reported dull, and, in fact, is at the moment solely confined to odd transactions to meet immediate or emergency requirements. For the present, however, ironmasters are under no urgent necessity to solicit new business, furnace outputs being, almost without exception, booked forward over the current half-year. It is, moreover, questionable whether new orders of any substantial tonnage could be secured at the extreme range of prices representing current quotations, which are actually 7s. 6d. per ton for Cleveland No. 3 foundry quality iron more than for Scottish makes. Generally, of course, these conditions are in reversed order on the Glasgow market. The position on Tees-side is naturally affected by the abnormal high cost of fuel in the district, where coke is as dear as ever, supplies for ironworks being quoted up to 44s. and in cases even as high as 46s. per ton.

Now that the two furnaces at Thornaby Ironworks are producing there are 20 blast furnaces engaged upon the output of East Coast hematite, and supply has already more than overtaken the demand. Makers are now keen for orders to replace expiring contracts, and whilst the nominal rates are 122s. 6d. per ton for mixed numbers and 123s. 6d. for No. 1, it is possible that these prices might be shaded for a good order. Little business was passing in the Cumberland and North Lancashire hematite pig-iron market last week, and prices have eased slightly again, Bessemer mixed numbers being quoted at £6 12s. 6d. per ton delivered at Glasgow and Sheffield, and at £6 15s. Liverpool.

MANCHESTER.—Movements in the local pig-iron market have been without any noteworthy feature of importance for some time, and last week's business was no exception to the general rule. Most foundrymen in the district are in the fortunate position of holding contracts for deliveries over the quarter end at considerably lower prices than those now currently quoted, and are consequently in no great hurry to close further commitments in the unsettled conditions of the market. Demand for Scotch iron in Lancashire has been checked by the recent high prices ruling.

THE MIDLANDS.—In the South Staffordshire area ironmasters report that although outputs are going away satisfactorily, new business is practically at a standstill. Consumers, having concluded that prices have reached the maximum, are not disposed to buy beyond the period for which they are covered at present, and there is very little inquiry for supplementary material for prompt delivery. Smelters are not disposed to take quite so disheartening a view of the outlook.

SCOTLAND.—The growing conviction that some reduction in pig-iron prices is imminent has greatly restricted business at Glasgow market, and transactions have been on a minimum scale. Export inquiry has shrunk to almost vanishing point, whilst there is more iron offering from the Continent.

Finished Iron.

Conditions in this branch of the iron trade have, of late, developed a somewhat irregular tendency, with new orders more difficult to obtain than has been the case for some time past. This may be perhaps explained by an increase of outside competition, Belgian bars for nut and bolt material being now on the market at much below current home prices. The marked bar houses are, however, reported to be very well sold and fully employed, and some of the makers of best crown bars are in the same position, though even in this branch others have left themselves rather short of contracts.

Steel.

Activity in most branches of the steel industry is well maintained, the demand for semi-products showing but little diminution from recent reports, while constructional and railway material orders are now on a more satisfactory average, owing to heavy contracts being placed for renewals of rolling stocks and permanent way requirements. In the market for alloys the situation in ferro-manganese is still unchanged, and inquiries from abroad, running into hundreds of tons per week, are circling round in quite unusual channels in the attempt to find new sources of supply.

Scrap.

Somewhat easier conditions have prevailed in the markets for scrap material of late, the general demand having been less active, with dealers more inclined to press sales than has recently been the case. In the Lancashire area the slow demand for cast scrap is an unusual experience, as this is now the cheapest possible material for the ironfounder. Not so long ago dealers in this section of the trade were complaining that the most they could obtain for good cast scrap was £5 per ton, when common pig-iron was costing £6 in most foundry districts. Now pig-iron may be about 2s. 6d. cheaper, but good scrap can be bought at 15s. cheaper, so that instead of coming together the two materials suitable for foundry work are drifting still further apart. Apparently about 85s. per ton is all that the dealer can now obtain for good broken machinery metal, and even at this low figure there is no demand worth speaking of. A little more is asked for the best lots of broken textile machinery metal, of which there is not an ample supply; but the quantity of good ordinary cast scrap available is large, and seems to be increasing.

Metals.

Copper.—Some depreciation of values has been marked in standard copper during the past week, but the undertone remains fairly firm, and it is now considered that the long spell of liquidation is now exhausted. The position in America is decidedly interesting at the moment. Consumers there are still working on an active scale, but they are inclined to restrict purchases at the moment in case prices should go lower. Recently, although the price of electro in New York was reported to have been put down to 16⅜ cents, private advices indicated rather better conditions on the market there; it remains to be seen whether this better tone is carried further. Current quotations:—*Cash*: Wednesday, £68 10s.; Thursday, £68 5s.; Friday, £67 7s. 6d.; Monday, £65 17s. 6d.; Tuesday, £65 7s. 6d. *Three Months*: Wednesday, £69 2s. 6d.; Thursday, £69; Friday, £68 5s.; Monday, £66 12s. 6d.; Tuesday, £66 2s. 6d.

Tin.—With only a quiet demand, both on home and Continental account, the market for standard tin has been an extremely difficult one to gauge owing to the extensive manipulations by interests in the East, in the United States, and here. In the circumstances it is not surprising that consumers have to a large extent kept out of the market. The American takings for the first four months of this year, totalling over 26,000 tons, were considerably in excess of all previous records, and American consumption will doubtless continue the main sustaining factor for some time to come. While the unshipped Eastern surplus is a great deal less than it was early last year, the fact deserves notice that the present visible supply is about 2,000 tons less than at this time last year. Statistical factors on this side are now more duly taken into consideration; the stock of Straits tin having been continuously encroached upon is now getting very small, and probably another month will elapse ere any important fresh arrivals can be expected in London. Current quotations:—*Cash*: Wednesday, £206 10s.; Thursday, £207 15s.; Friday, £205; Monday, £199; Tuesday, £197 5s. *Three Months*: Wednesday, £206 10s.; Thursday, £207 15s.; Friday, £204 10s.; Monday, £197 10s.; Tuesday, £195 10s.

Spelter.—The market for this metal continues depressed, with values tending to declining levels. Official stocks at the end of April totalled at 1,238 tons, which compares with 838 tons at the close of March. The market is in a very sensitive condition, and failing an immediate improvement on the consumptive demand, further recessions in values are not unlikely. Current quotations:—*Ordinary*: Wednesday, £31; Thursday, £30 17s. 6d.; Friday, £30; Monday, £29 15s.; Tuesday, £29 10s.

Lead.—Quotations for soft foreign pig have receded to lower figures, with business exceedingly quiet. Dealings with consumers are on a limited scale, and metal more than sufficient to cover requirements continues to arrive. The market on the Continent is poor. In America the price has been further reduced, but even so, it is still much above London parity, and conditions there for the time being exert but little influence on the London market. Current quotations:—*Soft foreign (prompt)*: Wednesday, £24 10s.; Thursday, £24 12s. 6d.; Friday, £25; Monday, £25 2s. 6d.; Tuesday, £25 2s. 6d.

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	£	s.	d.
Standard cash	65	7	6
Three months	66	2	6
Electrolytic	75	0	0
Tough	70	0	0
Best selected	70	0	0
Sheets	106	0	0
India	93	0	0
Wire bars	76	0	0
Do. May	76	0	0
Do. June	76	0	0
Ingot bars	76	0	0
H.C. wire rods	80	0	0
Off. aver., cash, Apr.	73	4	8½
Do. 3 mths., Apr.	74	0	9
Do. Settlement Apr.	73	4	0
Do. Electro, Apr.	81	11	3
Do. B.S., Apr.	77	13	1½
Aver. spot price, copper, Apr.	73	3	6
Do. Electro, Apr.	81	16	0
Solid drawn tubes		14½d.	
Brazed tubes		14½d.	
Wire		11d.	
Yellow metal rods		7½d.	
Do. 4x4 Squares		9d.	
Do. 4x3 Sheets		10d.	

BRASS.

Solid drawn tubes	12½d.
Brazed tubes	14d.
Rods, drawn	11½d.
Rods, extruded or rolled	7½d.
Sheets to 10 w.g.	11d.
Wire	10½d.
Rolled metal	10½d.

TIN.

	£	s.	d.
Standard cash	197	5	0
Three months	195	10	0
English	197	5	0
Bars	199	5	0
Chinese	194	5	0
Straits	202	5	0
Australian	201	15	0
Eastern	202	0	0
Banca	200	15	0
Off. aver., cash, Apr.	213	4	1½
Do. 3 mths., Apr.	213	11	11½
Do. Sttlment, Apr.	213	3	3
Aver., spot, Apr.	213	1	9

SPELTER.

	£	s.	d.
Ordinary	29	10	0
Remelted	28	0	0
Hard	26	0	0
Electro 99.9	34	10	0
English	31	5	0
India	27	0	0
Prime Western	30	5	0
Zinc dust	47	0	0
Zinc ashes	12	0	0
Off. aver., Apr.	34	6	8½
Aver., spot, Apr.	34	5	5½

LEAD.

	£	s.	d.
Soft foreign ppt	25	2	6
English	26	5	0
Off. average, Apr.	27	0	2½
Average, spot, Apr.	26	19	1½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	40	0	0
Do. V.M. ex whf.	40	0	0
Dutch	35	0	0
Rods	47	0	0
Boiler plates	39	0	0
Battery plates	40	0	0

ANTIMONY.

	£	s.	d.
English regulus	30	10	0
Special brands	36	15	0
Chinese	26	10	0
Crude	23	10	0

QUICKSILVER.

	£	s.	d.
Quicksilver	10	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
45/50% £13 12 6
75% £20 17 6
Ferro-vanadium—
35/40% 16/6 to 16/9 lb. va.
Ferro-molybdenum—
70/75% c. free 9/- to 9/3 lb.
Ferro titanium—
23/25%, carbonless 1/2 lb.
Ferro-phosphorus, 20/23%, £29
Ferro-tungsten—
80/85%, carbon free 1/5½ lb.
Tungsten metal powder—
98/99% 1/6½ lb.
Ferro-chrome—
4/6% car. £23 10
6/8% car. £22 10
8/10% car. £21 10
Ferro-chrome—
Max. 2% car. £50 0
Max. 1% car. £60 0
Max. 0.70% car. £70 0
67/70%, carbonless 1/6 lb.
Nickel—99%, cubes or pellets £135 0
Cobalt metal—98/99% 12/3 lb.
Aluminium—98/99% £115
Metallic Chromium—
96/98% 4/6 lb.
Ferro-manganese (net)—
76/80%, loose £18
76/80%, packed £19
76/80%, export £20
Metallic manganese—
94/96%, carbonless 2/- lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten £2 6
Finished bars, 18% tungsten £3 0
Per lb. net, d/d buyers' works.
Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ¾ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness 3d. lb.
Bevels of approved sizes and sections 6d. lb.
If in coils 3d. lb.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces 3d.
Turnings and swarf 1d.
Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy steel	4	10	0	5	0	0
Bundled steel & shrngs.	4	0	0	4	15	0
Mixed iron & steel	4	5	0	4	10	0
Heavy cast iron	4	0	0	4	5	0
Good machinery for foundries	4	0	0	4	10	0

Cleveland—	£	s.	d.
Heavy steel	4	11	3
Steel turnings	3	15	0
Cast-iron borings	3	15	0
Heavy forge	5	6	3
Bushelled scrap	4	15	0
Cast-iron scrap	4	10	0

Lancashire—	£	s.	d.
Cast-iron scrap	4	5	0
Heavy wrought	4	17	6
Steel turnings	3	12	6

London — Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	63	0	0
Brass (clean)	37	0	0
Lead (less usual draft)	21	0	0
Tea lead	19	0	0
Zinc	21	0	0
New aluminium cuttings	70	0	0
Braziery copper	53	0	0
Gun metal	50	0	0
Hollow pewter	170	0	0
Shaped black pewter	90	0	0

PIG-IRON.

N. E. Coast—
Foundry No. 1 130/-
Foundry No. 3 125/-
Forge No. 4 115/- to 117/6
Mottled —
Hematite No. 1 123/6
Hematite M/Nos. 122/6
Midlands—
Staffs. common —
,, part-mine forge —
,, ,, foundry —
,, Cold blast, ord. 190/-
,, ,, roll iron 200/-
,, basic —
Northants forge 97/6 to 100/-
,, fdry. No 3 107/6 to 110/-
,, basic 115/-
Derbyshire forge 105/- to 107/6
,, fdry. No. 3 110/- to 115/-
,, basic 115/-
Scotland—
Foundry No. 1 120/-
,, No. 3 117/6
Hematite M/Nos. 125/-
Sheffield (d/d district)—
Derby forge 108/6 to 111/-
,, fdry No. 3 113/6 to 118/6
Lincs. forge 110/-
,, foundry No. 3 115/-
,, basic 120/-
E.C. hematite 134/9
W.C. hematite 132/6 to 135/-
All d/d in the district.
Lancashire (d/d eq. Man.) —
Derby forge —
,, foundry No. 3 126/-
Northants foundry No. 3 —
Cleveland foundry No. 3 —
Staffs. foundry No. 3 —
Lincs. forge —
,, foundry No. 3 —
Dalzell, No. 3 134/6
Summerlee, No. 3 134/6
Glengarnock, No. 3 134/6
Gartsherrie, No. 3 134/6
Monkland, No. 3 134/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (cr.)	£12 to 12	10	0
Angles	12	5	0
Tees to 3 united ins.	12	10	0
Nut and bolt	11	10	0
Hoops	15	10	0
Marked bars (Staffs.)	14	10	0
Gas strip	13	0	0
Bolts and nuts, ¾ in. × 4 in.	20	10	0

Steel—			
Ship plates	10	10	0
Boiler plates	14	0	0
Chequer plates	11	5	0
Angles	10	0	0
Tees	11	0	0
Channels	10	5	0
Joists	10	0	0
Rounds & squares 3 in. to 5½ in.	11	15	0
Rounds under 3 in. to ¾ in.	11	10	0
Flats, over 5 in. wide and up	12	0	0
Flats, 5 in. to 1½ in.	11	5	0
Rails, heavy	10	10	0
Fishplates	14	10	0
Hoops (Staffs.)	13	0	0
Black sheets, 24 g.	14	12	6
Galv. cor. sheets, 24 g.	19	10	0
Galv. fencing wire, 8 g. plain	18	5	0
Rivets, ¾ in. dia.	14	15	0
Billets, soft	£9 to 9	2	6
Billets, hard	10	15	0
Sheet bars	£8/10/0 to 8	15	0
Tin bars	9	2	6

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 3½
Sheet	1 4½
Wire	1 4½
Rods	1 3
Tubes	1 6½
Castings	1 1½

Delivery 3 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.
CHARLES CLIFFORD & SON, LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/4 to 1/10
To 18 in. wide	1/4½ to 1/10½
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6½ to 2/0½
Ingots for spoons and forks	9d. to 1/3
Ingots rolled to spoon size	1/- to 1/6
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	32.76
No. 2 foundry, Valley	31.00
No. 2 foundry, Birm.	27.00
Basic	32.77
Bessemer	32.77
Malleable	32.77
Grey forge	32.27
Ferro-manganese 80% delivered	125.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y, at mill	43.00
Bess. billets	45.00
O.-h. billets	45.00
O.-h. sheet bars	45.00
Wire rods	51.00
	Cents.
Iron bars, Phila.	2.82
Steel bars	2.40
Tank plates	2.50
Beams, etc.	2.50
Skelp, grooved steel	2.50
Skelp, sheared steel	2.50
Steel hoops	3.30
Sheets, black, No. 28	4.00
Sheets, galv., No. 28	5.25
Sheets, blue an'l'd, 9&10	3.25
Wire nails	3.00
Plain wire	2.75
Barbed wire, galv.	3.80
Tinplate, 100-lb. box	$6.00

COKE (at ovens).

Welsh foundry 40/- to 45/-
,, furnace 30/- to 35/-
Durham & North. fdy. 47/6
,, furnace 39/6
Other Districts, fndy 45/- to 47/6
,, furnace 32/6 to 37/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	23/7½
,,	28×20, ,,	47/3
,,	20×10, ,,	34/-
,,	18¾×14, ,,	24/-
C.W.	20×14, ,,	21/10½
,,	28×20, ,,	44/10½
,,	20×10, ,,	31/3
,,	18¾×14, ,,	22/4½
Terneplates	28×20, ,,	43/6

TUBES.

Up to and incl. 6 in.

Gas .. ..57½% } Tube prices
Water ..52½% } are
Steam ..47½% } now free.

SWEDISH IRON.

Bars, hammered basis sizes—Basis price £22 to £23

Rolled Ordinary—Assortment .. } £ s. d.
Nail Rods—Square, round and flats .. } 17 10 0 to 18 0 0

Keg Steel nom. £38 to £40
Faggot Steel nom. £30 to £32
Blooms—
Single welded .. £10 to £11
Billets—
Single and double welded .. .. £13 to £14
Pig-iron—
Grey, white or mottled £7 to £7 5 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
May	9	68	10	0	dec. 22/6
„	10	68	5	0	„ 5/-
„	11	67	7	6	„ 17/6
„	14	65	17	6	„ 30/-
„	15	65	7	6	„ 10/-

Electrolytic Copper.

May	9	79	0	0	dec.	5/-
„	10	78	15	0	„	5/-
„	11	78	0	0	„	15/-
„	14	76	0	0	„	40/-
„	15	75	0	0	„	20/-

Standard Tin (cash).

May	9	206	10	0	No change	
„	10	207	15	0	inc.	25/-
„	11	205	0	0	dec.	55/-
„	14	199	0	0	„	120/-
„	15	197	5	0	„	35/-

Tin (English ingots).

May	9	206	10	0	No change	
„	10	207	15	0	inc.	25/-
„	11	205	0	0	dec.	55/-
„	14	199	0	0	„	120/-
„	15	197	5	0	„	35/-

Zinc Sheets (English).

May	9	41	0	0	No change	
„	10	41	0	0	„	
„	11	41	0	0	„	
„	14	40	0	0	dec.	20/-
„	15	40	0	0	No change	

Spelter (ordinary).

May	9	31	0	0	dec.	16/3
„	10	30	17	6	„	2/6
„	11	30	0	0	„	17/6
„	14	29	15	0	„	5/-
„	15	29	10	0	„	5/-

Lead (English).

May	9	25	15	0	dec.	5/-
„	10	25	15	0	No change	
„	11	26	0	0	inc.	5/-
„	14	26	5	0	„	5/-
„	15	26	5	0	No change	

AVERAGE MONTHLY PRICES OF EAST COAST HEMATITE MIXED NUMBERS F.O.T.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1915	83 11	88 6	94 8	107 0	102 6	101 3	98 9	98 7½	96 6	104 0	124 1	130 0	106 11½
1916	133 9	140 0	136 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	128 6	128 1½
1917	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1918	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1919	122 6	122 6	122 6	122 6	179 2	190 0	197 6	200 0	200 0	200 0	200 0	200 0	171 4
1920	220 0	220 0	240 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	251 8
1921	240 0	220 0	180 0	180 0	180 0	160 0	160 0	160 0	137 0	127 6	117 6	104 6	162 2
1922	97 6	91 7½	100 0	98 6	97 1½	94 7	93 6	90 9	89 7	91 10½	93 0	93 2	94 5½

AVERAGE PRICES OF STEEL RAILS.

Year.	Jan.	Feb	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1908	6 2 6	6 0 0	6 0 0	5 15 6	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 10 0	5 16 3
1909	5 5 0	5 5 0	5 5 0	5 0 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0
1910	5 5 0	5 7 6	5 7 6	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 8 11½
1911	5 15 0	5 15 0	5 15 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 13 1½
1912	5 13 1	5 15 0	5 15 0	5 15 7	6 1 6	6 6 3	6 7 6	6 8 0	6 11 3	6 12 6	6 12 6	6 13 9	6 4 4
1913	6 15 0	6 14 4½	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 10 0	6 10 0	6 10 0	6 12 0	6 12 0
1914	6 10 0	6 10 0	6 6 3	6 0 0	6 0 0	6 0 0	5 14 0	6 2 6	6 13 9	6 12 0	6 7 6	6 7 6	6 5 3½
1915	6 10 6	6 17 6	7 5 0	7 12 6	7 12 6	7 17 6	8 17 6	9 2 6	9 2 6	9 2 6	9 7 6	10 10 6	8 6 6½
1916	10 19 4	11 0 0	11 0 0	10 18 9	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 9 10
1917	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1918	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1919	10 17 6	13 7 6	13 7 6	15 0 0	15 10 0	16 0 0	16 10 0	16 10 0	16 10 0	16 10 0	17 5 0	14 12 11	
1920	18 15 0	19 5 0	20 7 6	22 0 0	23 0 0	23 0 0	24 0 0	25 0 0	25 0 0	25 0 0	25 0 0	22 18 11½	
1921	23 5 0	20 4 0	18 0 0	17 0 0	15 0 0	15 0 0	14 0 0	14 0 0	11 12 6	10 10 0	10 0 0	15 4 3	
1922	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 0 0	8 15 0	8 15 0	8 15 0	9 4 2	

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

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SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

IRON & STEEL SCRAP

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM COLVIN & COMPANY,

ROYAL EXCHANGE, MIDDLESBROUGH.

93, HOPE STREET, GLASGOW.

SMALL ADVERTISEMENTS.

Notice.

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 7 words per line. Minimum charge for one insertion 3/-.

SITUATIONS VACANT AND WANTED.

FOUNDRY MANAGER (age 36) desires position as Manager or Foreman; 23 years' experience of all branches of the trade; 12 years' special experience in production of high-grade Motor and Aero Castings in Iron, Aluminium, and Brass.—Box 448, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

METALLURGICAL CHEMIST, with practical experience, and capable of taking charge of Laboratory, desires engagement at a Foundry or Ironworks.—Write Box 7439, Williams's Advertisement Offices, Bradford.

ASSISTANT FOREMAN MOULDER wanted for Brass Foundry in North of England; must be experienced in large Liner Castings and have a general knowledge of Commercial work.—Write full particulars of experience, age and wage required, enclosing copies of recent testimonials, to Box 460, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5 Duke Street, Adelphi, London, W.C.2.

AGENCIES.

AGENTS wanted for all parts of the country, on a commission basis, to sell a Refractory Lining for Cupolas, etc.; must have good connections amongst Iron and Steel Foundries.—Apply, giving full particulars, to Box 452, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PARTNERSHIPS.

ACTIVE PARTNER required for Foundry and Engineering Business, with about £1,000 capital; required for extension.—Box 458, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PUBLICATION.

ENGINEERING WORKS, FOUNDRIES and FOUNDRY PLANT.—Complete lists of the Engineers, Iron, Steel, Brass and Aluminium Founders in Great Britain and Ireland, and also classified lists of Manufacturers and Suppliers of all Foundry Plant and Requisites, is contained in "Ryland's Directory of the Colliery, Iron, Steel, Tinplate, Metal, Engineering, Hardware and Allied Trades." Published by Eagland & Co., Ltd., Bessemer House, Adelphi, London, W.C.2. Price 42s. bound in cloth, 52s. morocco, net.

MACHINERY.

MACHINERY, PLANT, &c.

Powerful PLANING MACHINE, to plane 14 ft. x 5 ft. x 4 ft., two tool boxes on cross slide, by J. Buckton & Co., Ltd.

Heavy Duty High Speed PLANING MACHINE, to plane 8 ft. x 3 ft. x 3 ft., two tool boxes on cross slide, by J. Butler & Co.

Powerful DOUBLE-GEARED BORING MACHINE, spindle 6 in. diameter, tapping motion, table 10 ft. 6 in. x 10 ft. 6 in., by J. Hetherington & Sons, Ltd.

Richards' 24 ft. x 3 ft. SIDE PLANING MACHINE, two tool boxes on arm, two tables, 30 in. x 48 in. x 27 in.

One 30 h.p. D.C. Shunt Wound MOTOR, by Messrs. The British Westinghouse Co., Ltd., Manchester, 100 volts, 840 revs., with starter, etc.

One 15 kw. GENERATING SET, Belliss and Morcom Engine, diameter of cylinders 4½ in. and 7 in., coupled to Compound Wound Generator, by Siemens, 105 volts, 150 amps.

One Horizontal DOUBLE-GEARED STEAM WINCH, by Clarke, Chapman, cylinders 7 in. x 10 in. stroke, link reverse motion.

Catalogue of Stock Machinery, 6,000 Lots. Free on application. Inspection invited.

THO · W. WARD, LTD.,
ALBION WORKS, SHEFFIELD.

ROOTS BLOWER for Sale, No. 3, by Thwaites, in good condition.—Apply, BLACKLEY, INGLIS & CO., LTD., Sandyhills, Shettleston, Glasgow.

TWO NEW RUMBLERS, strong and well finished; geared drive; £22. Root's Blower, large size, £7 10s., f.o.r.—Apply 554, Fishponds Road, Bristol.

MACHINERY.—*Continued.*

FOR SALE.

Two 300-kw. Belliss B.T.H. LIGHTING AND TRACTION SETS, compound wound; in first-class order, with Condensing Plant and Switchgear.

Two 500-kw. Belliss B.T.H. ALTERNATOR SETS, 2,000 volts, single-phase (Engines will be sold separately if required), with Condensing Plant.

Four Babcock Land Type BOILERS, 8,500 lbs. capacity, 160-180 lbs. press.

One Mixed-pressure Belliss TURBINE, with 1,000-kw. single-phase ALTERNATOR (2-phase carcase), 2,000 volts, 60 periods; and 333-kw., 500 volt D.C. GENERATOR, connected tandem, complete with CONTRAFLO CONDENSER and MOTOR-DRIVEN PUMPS.

One MOTOR GENERATOR, 250 kw., comprising single-phase Synchronous Motor, D.C. Compound Generator, 200 kw., and D.C. Shunt Generator, 150 kw.

COUNTY BOROUGH OF CROYDON ELECTRICITY WORKS, FACTORY LANE, CROYDON.

WANTED.—3-ton CUPOLA, with staging, ex London area preferred. Must be in good condition and cheap.—Box 464, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PROPERTY.

FOR SALE.—Well-established General Iron, Brass and Aluminium Foundry, near London, railway and tidal river. Now engaged upon Machinery, Builders' and Iron Castings.—Box 462, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PATENTS.

INVENTORS Advice, Handbook and Consultations Free. KING'S PATENT AGENCY, LIMITED, Director, B. T. King, Regd. Patent Agent, 146a, Queen Victoria Street, London; 36 years' references

The Proprietor of British Patent No. 144,625, dated June 9, 1919, relating to
IMPROVEMENTS IN UNDERFEED FURNACES,
is desirous of entering into arrangements, by way of licence or otherwise, on reasonable terms, for the purpose of exploiting the above patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois.

MISCELLANEOUS.

FILES.—Twenty tons of New Files by best American makers. Flat, Hand, Round, Square and Three-square in bastard; second cut and smooth; surplus stock; no reasonable offer refused.—Box 368, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

ENQUIRIES SOLICITED FOR PATTERNS; quotations by return. Our works are well-equipped for turning out good work at reasonable prices. Castings also supplied, if required, in all metals.—E. CLEGHORN, Pattern Works, St. Martin's Gate, Worcester.

HARRIS BROS.
(Late PETER HARRIS),
METAL BROKERS, MINERAL — AGENTS, and CARRIERS.—
BRIERLEY HILL, STAFFORDSHIRE

FOUNDRY REQUISITES.
Try our REFRACTORIES.
Ganister or Silica Bricks and Blocks (any shape or size). Sands, Cements, Ganister.—*Let us have your enquiries.*
THE CLEVELAND MAGNESITE & REFRACTORY CO., LTD.,
Normanby Brickworks, Normanby, Eston, Yorks.

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Our Specialty — *Not a Side Line.*
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The **BRITISH BINDERI CO., Ltd.** *Wharf Road, Wandsworth, S.W.18.*
Telephone: Putney, 984. Telegrams: "Bindercomp, Wands, London."